J. Nelson Spaeth

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FOREST RESEARCH [1]

By E. H. Frothingham

The advance of the fortunes of forestry that is taking place in the United States ought to warm the hearts of all foresters. It is particularly gratifying that so much attention is being paid to forestry education and research. The recent large endowments for forest research and the establishment of new Federal forest experiment stations, on an increased scale, are proof that in its forward progress forestry is gathering momentum.

This encouragement for forest research and education seems to imply an appreciation of the importance and difficulty of the problems which the comparatively new science of forestry must solve in the accomplishment of its task. We know that these problems are of two kinds. One kind goes deep into the factors of tree growth and is truly fundamental. The other calls for immediate solution to meet present-day needs, without taking time to go far into the search for basic causes. Both kinds fall naturally to the research man.

What should be the proper balance between these two kinds of research? At the forest experiment station with which I am connected, the question is being answered for us. The questions which we are called upon at this early stage in our history to answer have a good deal more to do with immediate solutions than they do with the determination of fundamentals. How long will it take to raise a commercial stand of hardwood on cove or ridge land? What species of trees will give best growth and biggest returns, with least risk of loss, on a given kind of soil? What is the nature of fire damage, and how serious is it? What must be done to reclothe our denuded spruce slopes, to

[1] Delivered at the dedication exercises of the Yale School of Forestry, February 23, 1924.

restore scenic attractivenes, protect stream sources, and produce revenue? Such questions must be answered with the least possible delay, and it must be admitted that, in answering them, ultra-refinement of processes is hardly in place; it is certainly not consistent with the present large-scale, loosely handled practice of lumbering. Thus, while the forest experiment stations are far from neglecting basic studies—some, in fact, have concentrated almost entirely upon them, with results of noteworthy scientific value—they will probably never get wholly away from extensive as contrasted with intensive methods.

That there is need for basic studies in forestry which far exceeds the capacities of all qualified agencies, goes almost without saying. There ought, therefore, to be the most efficient cooperation between these agencies, so that duplications may be avoided and the work so distributed that each part falls to the agency best situated to handle it. A few years ago a committee of the Society of American Foresters compiled the current research projects of the United States and Canada under the title of "North American Forest Research." [2] A coordinating board such as this should, in my opinion, be restored and maintained. The interchange of opinion, criticism, and results, the encouragement of isolated workers, and the stimulating "group consciousness" of men engaged in a common cause, which would thus be promoted, would certainly justify it.

In considering this matter the vastness of the field for research must be taken into account. The difficulty of isolating responsible causes from the complex of interacting factors is well known to those who have attempted it. The forest experiment stations will undoubtedly turn their attention more to this as they find their way out of the preliminary task of answering the questions of the moment. But even these latter are staggering in number. In any alignment of work that might be made, therefore, the forest schools, the endowed research institutions, the agricultural experiment stations, as well as the forest experiment stations, should all be considered as centers at which forest research, including its more fundamental aspects, may be advantageously promoted. The investigation of causes can not be undertaken on a scale commensurate with its importance unless the forest schools and other qualified agencies combine with the forest experiment stations

[2] North American Forest Research. Compiled by the Committee on American Forest Research, Society of American Foresters. Bulletin of the National Research Council, 1: 155-300. 1920.

for a carefully planned attack. How such a campaign should be conducted is a matter for more deliberate analysis of conditions and needs than could possibly be given here. It may be, however, that a statement of some of the problems in a particular region will suggest opportunities for fundamental studies by the forest schools, and it is therefore my purpose in this paper to bring to your attention a few of the subjects which have come before the Appalachian Station.

FOREST TYPE CLASSIFICATION IN THE SOUTHERN APPALACHIANS

The conduct of forest research, and especially the application of its results, emphatically demand workable classifications of forest types. When the Appalachian Forest Experiment Station came into existence in 1921, it found some of the most complicated sets of forest conditions that have ever fallen to a small group of foresters to deal with. Within its territory, which extends south from Pennsylvania to northern Georgia and from the Atlantic coast to middle Kentucky and Tennessee, there are six major topographic divisions, ranging 6,700 feet in altitude and 6 degrees in latitude. Naturally there are marked climatic and soil differences, giving rise to a great diversity of forest vegetation. In the mountains alone there are more than fifty tree species of recognized commercial importance and many lesser trees and tree-like shrubs which contribute to the complexity of the forest. Since there was no adequate forest type classification in existence when the Station was organized, one of its first jobs, in connection with the public requirements study, was to draw up a schedule of major type groups. Although there is not space here to describe these fully, a brief statement of them will aid in the discussion to follow.

A *spruce* type and four groups of predominantly hardwood types are recognized. The highest of these is the *upper moist slope* group, occupying high, moist ridges and north facing slopes. Its species are largely yellow birch, beech, sugar maple, and hemlock, with scattered white ash, black cherry, buckeye, red oak, and other species in mixture. Capping the lower ridges and dry, usually southerly slopes are the *dry slope and ridge* types characterized by chestnut oak, scarlet and other oaks, chestnut, pitch, table mountain and jersey pines, and other resistant species. Below these types comes the *cove and lower slope* group, containing the best forest lands and the greatest diversity of vegetation in the region. Yellow poplar and cucumber, white pine and hemlock,

walnut and cherry, white oak, red oak, chestnut and other species of commercial worth make splendid growth here in all sorts of combinations.

This comprehensive grouping of forest types is of course inadequate for the purposes of investigative work, and a somewhat finer classification of actual cover types is now being undertaken by the Southern Appalachian section of the Society of American Foresters. The forthcoming classification will reflect the needs of the times for simplicity and ready application by the layman, and will make no great pretense of showing ecological relations. If the scheme finally proposed is fairly discriminative without being too complicated it will be a big step in advance; but it will not tell us what we shall need to know about the origins, successions, and climaxes of our forest types. As soon as possible, thorough ecological studies should be undertaken, and for this purpose the need of natural areas of virgin timber, to serve as standards for silviculture and ecology is emphatic. Nearly all the studies of the Appalachian Station will contribute to the general fund of ecological knowledge, but the field is large enough and attractive enough to command the attention of specialists in ecology.

FOREST SITES AND YIELDS

Several years ago Profesor Roth proposed a plan of site classification to enable a comprehensive arrangement of all forest lands in the country as to productive capacity in terms of the species found on them.[3] Height of dominant stand at a stated age was the index proposed. It is true that volume, or better, the current annual volume increment, is the final criterion, but the localities where this could be determined are exceedingly few. Height, as the most site-sensitive and the least stand-sensitive factor of volume, is obviously the indicator which should be used in any such comprehensive scheme of sites. In the lack of yield data this will at least afford a means for judging the probable goodness or poorness of any site with reference to particular species on it.

Objections have, of course, been raised to this apparent transcendence of type by site. Without going into these, it is fortunately possible to cite a case in which height, not only at a stated age but at all ages beyond the juvenile period, has been applied to the construction of

[3] Roth, Filibert. Concerning site. Forestry Quarterly, 14:3. 1916.

preliminary yield tables with what, considering the needs and size of the region, I believe to be a good degree of usefulness and reliability.

Because of its presence in all the types considered the species originally chosen as an index was chestnut. It was found, however, that other intolerant species sufficiently resembled chestnut in height growth to permit the use of any one of them. We have, as a consequence, a system of five sites, ranging from best growth, in coves, to poorest growth, in the dry slope and ridge types. There were available 370 yield plots representing well-stocked stands of eight composition types.[4] These plots were graphically allocated to site according to age, on the basis first of height and then of volume per acre. Relatively few were thrown out for unconformity. There resulted a comprehensive yield table for southern upland hardwoods, applicable to all hardwood lands, from cove to ridge, excepting the northern hardwoods but otherwise regardless of composition. As to variety of composition, the tables verify Spaeth's conclusion that "in spite of wide variation in percentages of species in mixture, for a given age, site, and density the volume in board feet, cubic feet, and cords is constant." [5]

It is to be expected that the generalized yield tables for southern upland hardwoods will eventually be supplemented, rather than wholly superseded, by precise tables for individual species. The growth curves for individual species will show a greater or less degree of variance. Yellow poplar yield tables now being completed by McCarthy will, for example, show somewhat different height curves and yield values from those in the generalized tables. Ultimately, by Roth's plan, every commercial species should be given its proper place in a uniform system of sites, determined by its dominant height at a stated age. The plan has also been applied at the Appalachian Station in the classification of sites for southern white cedar, yield tables for which have been based upon height growth as a criterion of site.

The development of any such extensive plan as this will obviously require a wide coordination of research agencies. The problem must

[4] The plot yields were worked up under the direction of W. D. Sterrett from data secured in Maryland, Virginia, and farther south, mostly by W. W. Ashe and F. W. Besley. See Sterrett, W. D., A generalized yield table for even-aged, well-stocked stands of southern upland hardwoods. JOURNAL OF FORESTRY, 19:382. 1921.

[5] Spaeth, J. Nelson. Growth study and normal yield tables for second growth hardwood stands in central New England. Harvard Forest, Bulletin No. 2, 1920.

be attacked from a pragmatic rather than theoretical viewpoint, for the practical service which the system will render.

VARIATIONS IN DENSITY OF STOCKING

In the construction of these tables, as in other yield studies of individual species in pure stands, which are being made from the Appalachian Station, it has been found that the most uncertain and indeterminate factor is that of density of stocking. No satisfactory standard of normality has yet been set. The standards regarded in yield tables have been arrived at by graphic averaging, which groups on the basis of total basal area or total volume per acre without regard to the relation which exists between average basal area on the one hand, and number of trees per acre on the other. Furthermore, a common practice is to throw out arbitrarily sample plot yields which depart beyond a stated limit from the graphic average for the site, although a comparison of the dominant height on age with the volume on age may bring out considerably less inconsistency than may exist between the plots selected as the basis for the tables. A method of testing the consistency of individual plots as to density of stocking, by plotting dominant height on total basal area or on total cubic volume per acre, has been tried out at the Appalachian Station, and it appears to give promise as a means of detecting abnormally stocked plots.

The determination of optimum stocking will be possible only through careful analysis of the factors involved, or by comparison of a large number of measurements of existing stands. There may be a law which may be shaped into a rule for field classification as to character and degree of stocking, and its discovery would solve many of our problems in the construction of yield tables and in thinnings.

HARDWOOD FOREST MANAGEMENT

The third subject which I wish to discuss is that of hardwood forest reproduction and the replacement of an active growing stock.

The mountain hardwood forest is hard to kill. The greater part of it has been worked and reworked as new products entered the market, and a very large area has been repeatedly burned. As a rule, the trees, though crippled by decay, are left alive, defeating by their shade any immediate prospect of adequate replacement with an active growing

stock. Hardwood reproduction on the better sites is normally vigorous if it receives plenty of light; but the intolerance of shade exhibited by some of the best species is a serious handicap in competition with less tolerant species, especially under the added impediment of an overhead crown shade. The repeated cullings that the hardwood forest has undergone have undoubtedly resulted in a considerable reduction of prospective growing stock of better kinds, and much of that which exists is defective.

The problems involved in the replacement of partially wrecked woods by a thrifty and valuable growing stock are among the most important and difficult with which we have to deal. In planning a study of natural reproduction following different methods of cutting in the hardwood types, which was begun last year, three phases were recognized: (1) a preliminary survey, to determine the general status of hardwood reproduction in relation to past treatment of the forest; (2) an experimental phase, to ascertain by sample plots the character of reproduction after prescribed cutting methods, its natural and cultural development, the increment of the uncut stand, and the later development of the new stand; and (3) an investigative phase, aimed to demonstrate the underlying causes of all phenomena connected with reproduction. Considerable work has already been done on the first two major elements of the project, both by extensive strip and plot surveys and by permanent sample plots. It is the third phase which I wish to stress.

The investigation of factors ultimately responsible for forest reproduction or its failure covers a tremendous field. It extends into the climatic and soil relations of plants; their response to the environmental stimuli of air and soil moisture and temperature; physical and chemical nature of the soil; evaporation, frost, wind and kindred matters. It goes into physiological and biotic relations, such as are comprised in root competition, tolerance, seed production and viability, and the influence of soil bacteria. It deals with disease and insect infestations. There is hardly a branch of natural science which does not find here an application to a most important task. Before we can successfully analyze conditions and forecast results of processes with assurance it will be absolutely necessary to know a great deal more than we now know about the responses our many tree species make to their exceedingly diverse environments in the Southern Appalachians. Can the forest schools afford to forego this opportunity?

GROWTH AND THINNING

It may almost be said that forestry is postponing its advent until it can find an active growing stock to work with. The second growth of the Southern Appalachian region is constantly increasing in amount in spite of the handicaps it has to overcome. Thinnings are already practicable in some parts of the region, and the development of young stands for quality increment will undoubtedly soon have a wide-spread practical bearing. Experiments in thinning are consequently a logical part of the Appalachian Station's program.

Thinnings present a variety of most interesting incidental directions for research. One of these which has recently been followed by B. H. Paul of the Forest Products Laboratory, is the influence of growth conditions upon specific gravity of the wood of white ash. This study has shown, according to progress reports by Mr. Paul, that a definite change in specific gravity of wood accompanies a reduction in the rate of diameter growth of white ash trees. Trees from stands in which little or no thinning had been done showed a decrease in diameter growth accompanied by a considerable falling off in specific gravity of the wood. Trees from a stand thinned by logging 30 years previously showed a remarkable increase in rate of diameter growth after thinning, and the wood showed only half as much variation in specific gravity as that from the unthinned stands. The volume of wood produced during the last 30 years by five trees from the thinned stand was nearly double that produced during the same time by five trees from an unthinned stand of approximately equal age and with similar site conditions. The results of the study show that when other conditions are favorable, thinnings in a stand of white ash will not only assist in the continuation of a normal growth rate but will prevent a falling off in the specific gravity of the wood formed. This study indicates a line of investigation which may well be followed up for other species, and it also suggests a wealth of opportunity for research in the relation of growth to the physical and mechanical characteristics of wood. In addition to these there are, of course, the interesting comparisons of different methods of thinning with respect to species, site, and product, and the changes in form of trees as a result of thinning. The determination of growth laws for our species is awaiting intensive study of individual trees and long time sample plot experiments.

WEATHER IN RELATION TO FOREST FIRE HAZARD

In order to determine the feasibility of predicting periods of forest fire hazard two or more days in advance, a study of weather in relation to the occurrence and severity of fires is being made by the Appalachian Station. As carried so far, this study indicates that greater efficiency as well as economy in fire protection could be effected through the agency of a forest fire warning service. The subject has many interesting aspects from the standpoint of research, and its importance to forestry makes it worthy of wider investigation. Such research activity justifies the fundamental training of forestry students in the sciences, even such applied sciences as meteorology.

THE BILTMORE ESTATE PLANTATIONS

No discussion of forest research would be complete which failed to mention the forest plantations in the Vanderbilt Estate, at Biltmore, N. C. This is one of the first planting projects of any size to be undertaken in the United States. The existing plantations cover several hundred acres and are now from 14 to 33 years old, some of them having been started before Dr. C. A. Schenck's connection with the Estate, as forester. Conifers, particularly white pine, have done much better than the native hardwoods. A study of the plantations has been made by the Appalachian Station, and a forthcoming report will afford a key to the existing stands which will greatly facilitate their further study.

The subjects which have been briefly discussed on the preceding pages comprise only a part of the work of the Appalachian Station. The remaining projects can only be mentioned in passing. They include the study of fire damage to hardwood and pine stands; grazing damage to reproducing hardwoods; natural regeneration of spruce type cut-over lands and burned lands; planting experiments in the spruce type with various native and exotic species; and studies of the reproduction, growth, yield, and management of individual species—yellow poplar and southern white cedar. As stated earlier in this paper, these are being worked out with a view, principally, to immediate needs. This, of course, is not enough. Final results must await a much more complete knowledge than we now have of the factors responsible for the behavior of our species.

Although any process which gathers facts systematically and extracts principles from them is commonly recognized as research, so too, in my opinion, are the sporadic discoveries that are made, incidental to other activities, since the very recognition and reporting of them indicates an alertness to scientific precepts. The aspiring forestry student would do well to keep this in mind, for whether or not he proposes to specialize in research a knowledge of its aims and processes will be of inestimable value. The man who intends to make research his life work, must, of course, ground himself well in the principles of the underlying sciences which, as should be obvious, means an intensive training in physics and chemistry, as well as in even such applied sciences as meteorology.

Looking back over the two and one-half years of work of the Appalachian Station and considering the immense field for scientific endeavor which lies fertile in the Southern Appalachian forests, it is clearly evident that here is an opportunity for service far transcending the present capacities of any one research organization in the country. Is not this generally the case in the United States? In spite of recent progress in forest research, we are really only at the beginning of things. In this formative stage, much depends upon teamwork, union of forces, and consolidation of gains. How could this be better accomplished than by means of a research board, or institute, to act as a clearing house and coordinator of the major forest investigations throughout the country? A board representing all qualified forest research agencies ought to be of the greatest service by keeping track of the research needs of forestry as they appear, analyzing them, and presenting them for consideration, so that each participant in the concerted plan of attack may be able to include in its program those subjects upon which investigation is most needed.

As a starting point for further progress, the advantage of agreement among forest investigators as to certain concepts, and even methods, is beyond question. The forest research board would be the means by which such agreements, if at all possible, could be brought about. The standardization of forest sites upon some workable, comprehensive basis, for example, might well be sponsored by such a board. It is hardly necesary to say that such a board should have no dictatorial or mandatory powers, and that freedom of initiative for the individual research agencies should be very carefully safe-guarded. The value of agreement, in all ways possible, should, however, be kept constantly in mind; there are many ways in which our work may be greatly assisted by a common understanding as to certain of our methods and ends. An active and representative forest research board would greatly aid in accomplishing this.

SOME RECENT DEVELOPMENTS IN THE USE OF WOOD IN AIRPLANE CONSTRUCTION

By Walter M. Moore
Fairfield Air Intermediate Depot, Fairfield, Ohio.

The first mechanically successful airplane was completed in 1903 by Wilbur and Orville Wright of Dayton, Ohio, and the first flight was made by the Wright brothers at Kitty Hawk, North Carolina, in December, 1903. Thus the span of man's mastery of the air is little more than 20 years.

All airplanes (heavier-than-air) are built, in part, of wood (with the exception of the Junker and one or two other types); and the exacting requirements and rigorous specifications are so precise and indeed, so unusual, that the procurement of suitable wood for the manufacture of those airplane parts for which it is best fitted, has been attended with much difficulty.

Although the substitution of metal for wood in airplane construction has long been predicted, yet wood is still used in large quantities. While aluminum and steel have their fields of usefulness in airplane manufacture, it seems extremely doubtful that they will entirely replace wood throughout the industry.

Airships and balloons (lighter-than-air) need not be considered in this discussion. The structural members of rigid and semi-rigid airships are generally made of aluminum and its compounds, and practically no wood is used. Balloons have no wooden parts, except the baskets.

KINDS OF WOOD USED

The early airplanes were built of bamboo, held together with wires. One of these early "flying machines" was said to have been made of "fishing-poles and hay-wire."

Bamboo, at first thought, would seem to be ideal for aircraft, owing to its light weight and its flexibility. But it proved to be too flexible, and a stiffer wood was sought.

After considerable experimentation, it was found that two woods were unquestionably the best—ash was the most suitable for such parts

as bore the brunt of the burden, and spruce for the other parts. The airplane industry began its rapid development in the early days of the great war; and from 1914 until the present time, ash and spruce have been the two most favored woods for airplanes, spruce being used much more commonly than ash.

Spruce is preferred because of its straight grain, its uniform texture, the ease with which it may be dried to a low moisture content, its splendid working qualities, the length and toughness of its fiber, and its light weight. Almost all other coniferous woods may be used in place of spruce, and there is no valid reason why they should not be used if spruce cannot be obtained; but none of them have proven to be as suitable for general-purpose airplane woods. For example, Douglas fir is somewhat heavier, and the fibers are not as tenacious, so that it splits more easily; the southern yellow pines are so resinous that they do not hold glue very well; white pine, and more particularly sugar pine, is somewhat too soft; hemlock does not finish well; and so on through the list of conifers. Spruce is used for the long beams or spars of airplane wings for the same reason that it is used for the masts of sailing vessels; it is not necessary that a mast be as heavy as a bridge timber, but it should be as straight as an arrow, and it then can be held in place by cables. The wing beams are kept apart by compression struts, and are held together by wires, the tension of each wire being regulated by a specially designed brass turnbuckle.

Nearly all wooden parts are made as light as is consistent with strength. Some of the larger ones are made like a box, that is, six boards glued together forming the six sides. Where this method of fabrication is undesirable, the wood is "lightened" or hollowed out on the shaper, or by hand chisels and gouges, wherever possible; a cross-section of a piece so lightened has some resemblance to an I-beam. Many wooden parts have numerous openings, which, if circular, are bored with a drill, or if of irregular shape, are sawed out on a jig-saw; these are solely for the purpose of reducing the weight.

The statements in regard to making wooden parts as light in weight as may be, does not apply to propellers. A propeller is not only an air-screw, cutting its way through wind and rain, snow and sleet, but it is also a balance or governor, and as such, it must be fairly heavy.

In the United States, propellers are made of oak, walnut, cherry, birch, mahogany, poplar, and maple. ("Oak" propellers are usually made of quarter-sawed white oak; "walnut" is, of course, black walnut;

"cherry" means black cherry; "birch" is usually yellow birch; "mahogany" means anything from Philippine mahogany to the heavy, dark red Honduras mahogany; "poplar" is yellow poplar; and "maple" is sugar or hard maple.) Repeated tests have shown that birch makes the strongest propeller in practically every kind of test that may be applied to it. Oak and walnut are also very satisfactory; walnut is a little easier on wood-working tools, and takes glue more readily; oak is somewhat harder and heavier, and can stand more punishment. Cherry is also satisfactory; poplar somewhat less so, though it is believed to be safe for propellers not subject to heavy duty. Mahogany from Central America is all right; other varieties have a tendency to split or break, showing their unfitness for propellers.

In recent years many experiments have been made with a view to substituting other materials for wood in propeller-making. Steel aluminum and bakelite have been tried, and give promise of being satisfactory. Wooden propellers have occasionally broken while in use. A bakelite propeller has been known to split through the middle while in service, the two parts falling to the ground. No breakage of metal propellers in flight has yet been reported.

SPECIES OF WOOD PERMITTED BY AIR SERVICE SPECIFICATIONS

The following woods are, at present, permissible for use in aircraft construction, according to Specification 15020-C of the Army Air Service. This list, with minimum specific gravity for each species, was prepared at the Forest Products Laboratory at Madison:

	Name.	*Minimum specific gravity permitted.*
1	Ash, commercial white (*Fraxinus americana, F. lanceolata, F. quadrangulata*)	.56
2	Ash, black (*Fraxinus nigra*)	.48
3	Basswood (*Tilia americana*)	.36
4	Beech (*Fagus atropunicea*)	.60
5	Birch (*Betula lutea, B. lenta*)	.58
6	Cherry, black (*Prunus serotina*)	.48
7	Elm, rock (*Ulmus racemosa*)	.60
8	Gum, red (*Liquidambar styraciflua*)	.48
9	Hickory (*Hicoria glabra, H. laciniosa, H. alba, H. ovata*)	.73
10	Mahogany, true (*Swietenia mahogani*)	.46

Name.	Minimum specific gravity permitted.
11 Mahogany, African (*Khaya senegalensis*)	.46
12 Maple, hard (*Acer saccharum*)	.60
13 Oak, commercial white (*Quercus alba, Q. macrocarpa, Q. minor, Q. michauxii*)	.65
14 Poplar (*Liriodendron tulipifera*) including Cucumber (*Magnolia acuminata* and *M. foetida*)	.38
15 Walnut, black (*Juglans nigra*)	.52
16 Cedar, Port Orford (*Chamaecyparis lawsoniana*)	.42
17 Douglas fir (*Pseudotsuga taxifolia*)	.45
18 Fir (*Abies amabilis, A. grandis, A. nobilis, A. concolor*)	.38
19 Hemlock, western (*Tsuga heterophylla*)	.40
20 Pine, sugar (*Pinus lambertiana*)	.36
21 Pine, western white (*Pinus monticola*)	.40
22 Pine, white (*Pinus strobus*)	.36
23 Pine, Norway (*Pinus resinosa*)	.46
24 Spruce, red, white, Sitka (*Picea rubens, P. canadensis, P. sitchensis*)	.36

The above list shows that many woods have been added to the original favorites, spruce and ash. In actual practice, such species as beech, cucumber, elm, basswood, Norway pine, hemlock, fir, and Port Orford cedar are seldom used.

USE OF PLYWOOD

The following species are permissible in plywood for airplanes, according to Army Air Service specification 15034-D:

For faces, cores, and cross-banding:

- Yellow poplar.
- Basswood (northern).
- Redwood.
- White pine.
- Spruce.
- Fir (grand, noble or silver).
- Western hemlock.

For faces only:

- Birch.
- Maple.
- Beech.

For faces only—*Continued:*
Mahogany.
White elm.
Sycamore.

The use of plywood in airplane construction was developed on an extensive scale in 1918, in connection with the building of several thousand DeHaviland airplanes. The top, bottom, and sides of the DeHaviland fuselage were built of three-ply material, usually about one-eighth inch thick, the outside plies being birch or mahogany, the inside ply being soft maple, poplar, basswood, spruce, gum, cottonwood, or almost any other word. In addition, the three forward "bulkheads" were made of 15-ply material, 1 inch thick, made of alternate plies of hard and soft wood. These 15-ply "boards" are exceptionally strong and heavy; they can scarcely be broken, and they can not be split with an axe. They can be sawed with difficulty, the hardened glue retarding the saw so much that it soon becomes overheated, unless it is run at a speed somewhat slower than usual.

The wing webs of the war-time DeHavilands were all made of plywood, usually not over one-quarter inch thick. Cut-outs were made in those portions of the webs where great strength was not required, so much so that some of them seemed to be made up mostly of great open spaces.

With an increase in the number of plies used for a given thickness, the more nearly homogeneous in its properties is the completed plywood. Improved methods in plywood manufacture have done much to increase the utilization of smaller sized material, as well as increasing the number of species that may be used, thus rendering available, for future airplane use, a vastly greatly amount of wood than would otherwise be the case.

In making plywood, the common method is to use alternate laminations of hard and soft wood, for the reason that tighter glue joints can thus be secured. Thus, we find yellow birch and yellow poplar, oak and spruce, mahogany and basswood, and the like. The outside or "face" plies are always of the harder wood. Plywood nearly always is made up of an uneven number of plies, and takes its name from the outside plies; thus we have one-quarter inch 3-ply birch, meaning that the finished plywood is one-quarter inch thick, and that the outside plies are birch. The grain—the direction of the wood fibers—of alternate plies should always be at right angles, reinforcing each other and thus preventing splitting.

A good example of solid wood being replaced by plywood is found in the new Airways DeHaviland (DH4B4) and the DeHaviland Photographic (DH4BP1). In the former, spruce struts have been taken out, and bulkheads of thick plywood have been put in; they stiffen the entire airplane, and provide a compartment strong enough to carry freight. In the latter, the bulkhead at the photographer's seat, the gusset plates at the top, and the cockpit floor, on which a heavy camera is mounted, are all made of thick plywood.

The complaint is sometimes heard that plywood or "veneer," as it is frequently called, will not stand wet weather, but that the glue will dissolve, and the plies will pull apart and curl up, or break off. This was true in 1918 when the old-style DeHavilands were shipped to France in the damp holds of ocean ships. The shipping crates were sometimes unpacked and the airplanes stored in the open air for months at a time, due to lack of warehouse facilities in France. It is indeed true that no glue will endure such trying conditions for an indefinite period; and the moist climate of France was very hard on some of our American built products. It is also true that propellers glued in France and apparently satisfactory in that country, were brought to the United States and fell to pieces after being stored for a few months in Alabama, indicating that their glues were unsuited to our drier (or warmer) climate. The climate of western Texas is very hard on propellers.

Plywood, or any built-up part, like a propeller, is no better than the glue that goes into it. In the past few years, there has been a great improvement in glues and glueing methods, and the water-resistant glues developed by the Forest Service have been of great value to the airplane industry. As a result of these improvements, little trouble is now being experienced with "veneer," providing ordinary precautions are taken. It is especially important that plywood be stored in a dry warehouse, especially if it may not be used for several months or years. It deteriorates more rapidly in damp storage than it does after it has been placed in service on an airplane, for it is then given the protection of several coats of paint or varnish.

An approved method of protecting the plywood on the outside of an airplane is to give it two coats of shellac, two coats of paint and one coat of varnish. With this protection, it can be flown through rain or snow without injury (except that a propeller suffers some damage by striking the raindrops at the high speed at which it revolves).

DEFECTS IN WOOD WHICH AFFECT ITS SUITABILITY FOR AIRPLANE MANUFACTURE

All materials that enter into airplane construction must be the best of their kind. The requirements of the airplane manufacturer are most exacting, and the specifications for all materials that he uses are unusually severe. This applies not only to wood, but to wire, rubber shock absorber cord, cotton fabric, linen thread, varnish, terne plate for gasoline tanks, copper tubing, and everything else that is required.

Each part must be made as light in weight as possible. Lumber that is suitable for ordinary construction, or even for fine furniture, may be altogether unsafe for airplane use. A new standard was set by the Army and Navy Air Services, the standard being so high as to discomfit those individuals and corporations from whom the lumber was purchased. In fact, the standard at first was *too* high; and the difficulty experienced by the Air Service in getting airplanes built fast enough was partly due to an insistence upon too rigid standards. We have found that we must take the wood as it grows; not as we would like to have it grow.

The most important requirement, from the standpoint of aviation, is *straightness of grain.* The "grain" means the direction of the longitudinal fibers of the wood. Wood will always split along the line of least resistance, that is, along the grain. For airplane use, the fibers of the wood should be parallel to the edge of the board, so that it may be as strong as possible. A cross-grained strut will split and fall apart, but one that is straight-grained, if it splits, will stay in place, both pieces remaining intact. The same is true of a straight-grained tool-handle.

It is easy to get straight-grained spruce, fir, or other coniferous woods. But it is difficult to get straight-grained hardwoods of any kind, as is well known by the manufacturers of hoe handles, baseball bats, and golf sticks. The Air Service specifications for hardwood lumber state that it must be "reasonably straight-grained;" it is often necessary to sort over a large quantity of such lumber in order to find a small number of clear pieces sufficiently straight-grained for manufacture into struts or longerons.

Diagonal Grain

"Diagonal grain" is said to occur when the fibers on the radial face of a piece of wood are not parallel to the planes of the saw cuts. The

radial face is a saw cut along a radius of the log, and is always the surface of a board where the annual rings are closest together; it is equivalent to the expressions "quarter sawn" or "rift sawn" or "vertical grain" lumber.

The greatest deviation from straight grain allowed for diagonal grain is usually 1 in 15. However, for highly-stressed parts, like a control stick or an interplane strut, absolutely straight grain, with no perceptible angle of deviation from a line parallel with the edges, is usually demanded, and it can be obtained by selecting the best pieces of wood, and leaving the other pieces for parts that are not subject to sudden stresses, like floor-boards, pyrene mounts, etc.

Wing beam stock 20, 24, or even up to 32 feet long, with grain that is parallel to the edge throughout the entire distance, is sought after, and can be obtained in the case of spruce or fir. But when it comes to getting ash longeron stock 16 feet long, with perfectly straight grain, it is a different matter, for hardwoods are rarely as straight-grained as conifers. Inspectors have learned to be satisfied with what they can get, instead of rejecting everything that falls short of perfection.

Spiral Grain

Any deflection of grain on a tangential face of a board (that is, the saw cut which is at right angles to a radius, or approximately so) is called "spiral grain." It can be most easily seen by observing the resin ducts. A slight amount of spiral grain is permissible. Excessive spiral grain gives a corkscrew appearance to a piece of timber; in the forest, trees are often observed with pronounced spiral flutings in the bark. In old dead stubs, spiral flutings can be seen in the wood of the tree-trunk. Such trees are virtually worthless for any purpose.

Wavy Grain

By "wavy grain" is meant a series of dips or curves in the annual rings, as shown on the radial face. A very slight amount of wavy grain is not considered a defect; but if the "waves" are found along the edge of the board, some of the annual rings will reach to the edge and form a weak spot in the board.

Curly Grain

A "curl" is a snail-like irregularity in the wood fibers. Curls are seldom associated with decayed wood, and they do not appreciably

affect the strength of the piece, unless they are found at the edge. A few small curls, well distributed, are allowable.

The latest specifications for propellers state that laminations are not suitable for propellers if they contain "pronounced burls or curls, or small ones not well scattered, which show on both faces, or on the edges."

Pitch Pockets

Pitch pockets, which are found in fir, spruce, and other softwoods, are openings, containing resin, between the annual rings. They are usually small, about an inch long, and one-eighth or one-fourth inch wide, but occasionally they are 6 or 8 inches long and an inch wide. Large pitch pockets are very objectionable, as they weaken the wood, and the resin, if it becomes heated on a warm day, runs out like liquid glue.

As a rule, all pieces containing pitch pockets should be rejected. In the case of wing-beams and other large parts, it may be difficult to find sufficiently large pieces of wood absolutely free from pitch pockets. Pockets not longer than one inch, whose full size is visible, are permissible if not closely grouped.

Sap Stain

Sapwood of both softwoods and hardwoods is often discolored. Certain stains are simply discolorations due to chemical action; a familiar example is the brown-stain of sugar pine. The strength of wood is not affected by this and similar stains.

Other stains are caused by fungi. Blue-stain is a common example of this class. It can be prevented by klin-drying the lumber as soon as it is cut.

Most stains, no matter how caused, are confined to the sapwood, and as they do not extend deeply into the wood, they can be planed off. Their effect on the strength of wood is negligibie.

Decay

All decayed portions of a board should be rejected, without any exception whatever.

Decays are caused by fungi of various kinds. Decayed wood may be brown, white, or other colors, and if well advanced is easily recognized; though the incipient stages in the life of the decay-producing organisms are not always readily perceived. Long experience in han-

dling and inspecting wood is necessary to recognize the early stages of decay, which is sufficient cause for rejection; for any decay, no matter how slight, weakens and disintegrates the wood fibers.

Knots

All of the principal wooden parts for aircraft should be entirely free from knots, as they always are a source of weakness. In wood that is to be built up into plywood, small "birdseyes," if well scattered, are allowable.

Worm-holes

Highly stressed wooden parts must be free from holes of all descriptions and this includes worm-holes. In the less important wood parts, or in pieces that are to be built up into plywood, a few scattered worm-holes are allowable, provided that they are not surrounded by unsound wood. If the holes turn and disappear from sight, the wood should be examined with special care.

Shakes

Shakes are separations in the wood fiber, usually along the annual rings. Shakes and all other splits and cracks are serious defects, and can not be allowed in any airplane part.

The fact has long been recognized that it is almost impossible to dry thick boards, especially wide ones, in the kiln without causing checks to appear at both ends of the boards, extending for an inch or more into the boards. The obvious remedy is to cut off the checked portion, after the drying process is completed.

Inasmuch as the natural stresses in the tree are somewhat relieved when the logs are sawed into lumber, and as small pieces may be kiln-dried without introducing new stresses, it follows that checking and splitting may be almost entirely prevented by sawing the timbers into comparatively small pieces before drying.

Small checks in air-dried lumber are not a cause for rejections; no air-dried lumber can be found that is entirely free from them. But when the lumber is manufactured, all checked portions must be planed or sawed off.

Honeycomb

If the surface of a board is dried too rapidly (in a kiln), the outside cells become rigid and "set," preventing moisture in the center of the board from passing out to the surface. The wood becomes "case-

hardened" (this term has been borrowed by foresters from the steel-makers) and radial checks appear in the interior of the wood. Such wood is unfit for aircraft use.

Collapse

When wet lumber is dried at too high a temperature, it "collapses," and becomes bent and distorted. This is caused by the cell walls becoming soft, and they lose their shape and flatten out, just as if an automobile radiator should become collapsed and flattened. Collapsed wood is altogether unfit for manufacture into aircraft parts.

Slight case-hardening, which often occurs during the process of kiln-drying, can be overcome by promptly increasing the humidity of the kiln, preferably by admitting live steam. If a kiln is correctly operated, no case-hardening, sufficient to cause checking, should take place.

Low Specific Gravity

The minimum specific gravity (based on oven-dry weight) for each species is given elsewhere in this paper. Increase of strength goes with increase of specific gravity, providing the wood is free from knots or other defects.

Wood whose density is below the minimum is generally "brash" or brittle, and lacks the strength requisite for aircraft use.

It should be remembered that wood which is not dry will, of course, be heavy, due to moisture contained therein, and may apparently have a high specific gravity. Wood with an abnormally high resin content will also be heavy, yet it will split easily.

Compression Failures

Airplane timbers, especially spruce, are frequently found with irregular wrinkles in a line at right angles to the grain. This probably occurs when the tree is felled. All wood in the immediate vicinity (a foot or so) of a compression failure must be rejected; the remainder of the stick is usually all right.

Excesive Moisture Content

When the moisture content of wood is reduced below the fiber saturation point, the strength and stiffness are increased. Shrinkage also takes place.

Green wood, it need scarcely be said, can not be used for aircraft work, as it will shrink, warp and check, and will not stay in place. In

addition, it can not be worked with hand tools; and it will tear itself to pieces if run through woodworking machinery. Air-dried wood, as a rule, is not suitable for aircraft work, as it will not stand machining operations, such as planing. Unless it is exceptionally well air-dried, it must be given a further drying in the kiln, preferably in one where humidity, temperature and circulation are under positive control.

Wood should contain from 6 to 12 per cent moisture for ordinary aircraft work; 15 per cent is not excessive; but for propellers, or for other work where glueing is required, it should be carefully dried to a uniform moisture content of 5 or 6 per cent. Wood with very much moisture can not be successfully glued.

In England, wood with a somewhat higher moisture content is permitted; 15 per cent for most woods, and 18 per cent for ash, with an allowable variation of 3 per cent. In war-time, both England and France specified against "kiln-drying" of airplane woods, as the humidity-controlled methods of kiln-drying were not then recognized abroad.

Defects Due to Steaming and Bending

In order to reduce the wind-resistance as much as possible, it is necessary to have a great many curved surfaces on an airplane. This requires the use of curved wooden pieces. If sawed to shape out of large timber, they would have little strength! it is necessary to take straight-grained strips, and bend them to the desired shape, without cutting any of the longitudinal fibers.

Ash and other hardwoods, before bending, must be steamed for an hour or more. After the steam has made the board soft and pliable, it is bent over a frame, clamped in place, and kept there for several days or longer.

In spite of the utmost care in steaming and bending, there is always some breakage. The airplane designers have sometimes expected too much of wood, and have designed curved members which ought never to have been made from bent wood. It is not reasonable to suppose that a board from a mature tree can stand as much distortion as a tiny twig.

If a curved member can not be made from a single piece of wood, it can usually be built up of thin strips which are easily bent, and are glued in place over a form having the desired curvature.

STORAGE OF AIRPLANE PARTS

In airplane factories, repair shops, and flying fields, a great deal is said about "dry rot," "brashy wood," and the like. Some of these remarks are due to prejudice against wood in general, and have little foundation in fact. Few instances have been brought to light in which deterioration has actually taken place, providing the wood was stored in a dry building with free circulation of air. If stored in a damp basement, or under a leaky roof, it would be expected that decay would take place.

It would be better if all wooden parts, and all lumber selected for future manufacture into airplane parts, could be stored under constant and favorable conditions of humidity and temperature. These two factors are readily controlled by steam heat, water sprays, and circulating fans. Devices for regulating humidity and heat are on the market, and are in use by manufacturers of food products, tobacco, cotton goods, and other commodities. Air-conditioning outfits employ blowers for circulating the air and for passing it through steam coils and water sprays.

At McCook Field, Dayton, Ohio, propellers are kept in a storage house where the air is maintained at 65 per cent relative humidity and 65 degrees Fahrenheit, although the temperature is not of great consequence. It is reported that before the air-conditioning apparatus was installed, "warping and checking while in storage has been one of the most serious defects of wooden propellers, for the finished propellers are still sensitive to humidity changes," but after it was installed it is stated that "this plant has been in service for some time, and the results obtained have been extremely satisfactory."

Varnish and paint are moisture retardants, but they do not entirely prevent moisture from going through. A "moisture equilibrium" becomes established inside of varnished wood parts the same as in unvarnished ones; though it takes longer in the case of varnished parts.

Most of the wooden parts that were manufactured in war-time are thoroughly sound and serviceable today, if they have been stored in dry buildings.

BALLOON BASKETS

Balloon baskets for Type R observation balloons are made up of a framework of wood and reeds, resting upon wooden runners, with

the bottom and sides of the basket made of reed or rattan. The runners are of second-growth hickory or of hard maple, hickory being preferred; the laminated strips forming the shoes of the runners are of hickory or white oak. The wooden toggles are made of clear stock of boxwood, hard maple, ash, or dogwood. The wooden portions of the basket frame are made of straight-grained, second-growth hickory, into which is woven rattan and "reed," another name for peeled rattan. Hickory stakes form the rounding corners of the basket, and the bottom of the basket consists of transverse sticks of hickory and of reed which pass through holes cut out for that purpose in the wooden runners.

METAL AIRPLANES

Airplanes built partly or wholly of metal are no novelty in Europe. The best known is the Fokker plane, named after its designer, Anthony Fokker, a Hollander, who tried to interest England and the United States in his inventions, but who met with no success until he went to Germany, some twelve years ago. The German Government accepted Fokker's airplanes, and built them in large numbers during the late war. They are built mainly of steel tubing, all joints being securely welded. The wings are of wood construction, the spars and webs being made of spruce, and the leading edges strengthened with very thin plywood. Both fuselage and wings are covered with cotton fabric, usually camouflaged with a crazy-quilt pattern of many colors.

Within the past two years a large number of new types of metal airplanes have been designed and built in the United States. Wooden wings are still retained (with a very few exceptions); but the fuselage—the body—is built of metal. The most important structural parts are of steel, and the less highly stressed parts are of duralumin, an alloy of steel and aluminum.

The principal advantage of metal as compared with wood is the uniformity of strength of metal parts, and the accuracy with which the stress analyses can be calculated. Another advantage of metal is its lack of moisture absorption. Still another is the fact that it will not burn.

Without denying the essential truth of the above claims for superiority of metal, and admitting that metal airplanes have been successful, the disadvantages should also be pointed out. Tubes, channels, I-beams and other shapes are unquestionable of uniform strength and quality;

but the welds are of variable degrees of perfection. The best welder cannot make them all alike. The condition known as "crystalization" is likely to occur in any metal part subject to continued vibration. Familiar instances of crystalization are found in band-saws, which are without a flaw when manufactured, but after long use suddenly become "crystalized" and snap in two. On airplanes, oil and fuel lines have sometimes broken from this cause, which is akin to the "fatigue" of metals.

Rust is an insidious enemy of all steel parts, especially the brace-wires and the control wires.

It thus happens that failure of metal parts during flight is just as likely to happen as failure of wooden parts. An instance of a failure of a metal part was the leak in the water-jacket of a Liberty engine, which happened on the flight of Lieutenants Kelly and Macready from San Diego to Indianapolis in the spring of 1923; this would have been a transcontinental flight if it had not been for this untimely occurrence. It will be recalled that Lieutenants Kelly and Macready made the non-stop transcontinental flight a few weeks later, going from New York to San Diego, a distance of 2,560 miles, in 26 hours and 50 minutes. This was on May 2 and 3, 1923.

When an airplane falls from a considerable height, and crashes to earth, neither wood nor metal can stand the shock, and one will break as quickly as the other.

Aluminum is approximately three times as heavy as ash or oak; steel is three times as heavy as aluminum; wood certainly has the advantage over metal where weight must be kept down. The specific gravity of iron castings fluctuates as widely as that of wood; the specific gravity of wrought iron and steel is more uniform. The statement which is often made by advocates of metal construction, to the effect that metal is absolutely homogeneous, and that its properties can always be calculated with extreme refinement of detail, is a rather broad assertion. Even when heat treatments are standardized and most carefully regulated, there is some variation in strength properties, and some of the newly developed steel alloys are spoken of as "nervous" alloys. Yet it must be admitted that alloys of better composition are constantly being developed, and welding practice is being improved. Even the most enthusiastic advocate of wood is slow to claim that wood of better composition is being grown.

If a very large production of airplanes—several thousand per week—should ever be required, it is possible that metal could be used more

advantageously than wood. In assembling a wooden fuselage, many thousands of wood screws must be used; holes must be drilled and countersunk before the screws can be inserted, especially where plywood is employed; many glueing jobs must be performed (even though the plywood has been previously been glued up); and metal fittings must be affixed in large numbers. These operations require much hand work, and there is a limit to the amount of "speeding up" that can be accomplished. Wooden parts can not be molded or stamped, as metal parts can; they must be sawed out.

When metal airplanes are built in quantities, the parts can be quickly cast or stamped out, set up in jigs, and welded at the proper places.

THE LARGEST AIRPLANE

The world's largest airplane, the Barling Bomber, with a wing spread of 120 feet, a weight of 40,000 pounds (fully loaded) and a carrying capacity of 10,000 pounds, is built entirely of wood, except for the wires, fuel tanks, and other parts for which wood could not be used. This huge airplane was assembled at Fairfield, Ohio, and was completed in August, 1923. It is now in successful operation. Spruce is the wood that is chiefly used in its construction.

Walter H. Barling, its designer, was asked why he built it almost exclusively of wood. He replied as follows: "It is hard to design as cheaply in metal as in wood, especially if welding in direct tension is prohibited. as it ought to be, in the opinion of many engineers."

PRESENT TENDENCIES IN DESIGN

At the Paris Aero Exposition for 1923, where the latest models were exhibited, it was noted that few radical developments in wood construction were apparent. In other words, all of the new wooden airplanes either were built along ordinary lines—that is, a framework of longerons and struts, strengthened with brace wires, and covered with cotton fabric—or else were built of plywood, reinforced with wood braces. More originality was shown in the metal airplanes.

Metal airplane construction has followed the usual practice in nearly every industry, in that when metal is first used to replace wood, the shapes and sizes of the wooden members are reproduced in metal. Later on, radical designs are worked out, differing greatly from the wood.

For example: in airplane wing construction, the first metal wings followed closely the approved methods of wooden wing building, two spars, with many rigid ribs, a curved leading edge, cross brace wires to provide tension, and a fabric cover for the whole. In recently-designed metal wings, a large number of spars are used. The spars are connected by light strips of metal which are curved to form the outline of the wing; and the ribs and brace wires are dispensed with altogether.

The tendency for the past 6 or 7 years has been to make the wings thicker, and several of the larger airplanes have enormously thick wings, providing accommodation for engines, passengers, and freight, all within the wings themselves. In fact, the whole airplane is transformed into a flying wing, with tail surfaces added for proper control.

In the "Wright All-Metal Pursuit Airplane" the only wooden part is the engine bed. Like wooden railway ties, such engine beds act as cushions as well as supports.

In the early part of the late war, European builders of aircraft used four-bladed propellers to a great extent, and three-bladed ones were occasionally used. The two-bladed propeller has been used almost exclusively in the United States. From an aerodynamic point of view, the two-bladed style is more efficient, because each blade enters a region of comparatively undisturbed air. But a multiple-bladed propeller has a smaller diameter, smaller peripheral velocity (and thus greater safety), and better ground clearance.

From the viewpoint of the manufacturer, the four-bladed type is more difficult to construct, as the hub splices must be fitted with extraordinary nicety, and the alignment and pitch of all four blades must be exact. In a two-bladed propeller there is, ordinarily, no splicing at the hub, as the laminations (the wooden pieces of which the propeller is built) extend throughout both blades.

WOOD VERSUS METAL IN AIRPLANE CONSTRUCTION

(1) Metal is more uniform than wood. Metal is cast iron, drawn, rolled or otherwise treated, and so is reduced to comparative uniformity. Wood is cut from the living tree trunk, and no two trees grow exactly alike.

(2) As to the reliability of metal and wood, there is considerable to be said in favor of wood for aircraft construction. Metal parts, sub-

ject to vibration, will crystallize and break, and welded joints may fail. Fracture of wood parts rarely occurs, except in a wreck.

(3) Wood is easily procured for emergency repairs. Any kind of wood may be used for temporary repairs; and it can be fashioned with ordinary tools.

(4) Wood has a "give-and-take" which metals do not possess.

(5) Weight for weight, wood is stronger than any metal (compression, tension, etc.).

(6) Weight for weight, thin metal will "crinkle" before wood will split; and a metal tube will buckle before a wooden stick of the same size will break.

(7) Metal can be cast or wrought in any shape, but it can not be built up with the ease that wood can be glued into laminated plywood.

(8) For experimental construction, wood is unsurpassed, as it can be quickly cut into any desired shape. For large scale production, metal is probably more desirable.

(9) Metal is fireproof; wood is not.

(10) Wood is subject to decay; metal is not. Ferrous metals, however, are subject to rust; and even duralumin will oxidize to some extent.

Thus we see that the advantages and disadvantages of wood and metal are rather evenly balanced.

SUMMARY AND CONCLUSIONS

(1) Wood is well adapted for airplane construction, because of its lightness and strength, and the ease with which it can be worked. Wood must be straight-grained, of suitable density, and free from defects.

(2) Nearly all of the earlier airplanes, and many of the later ones, are built entirely of wood, with the exception of fittings, brace-wires, control-rods and other parts for which wood is obviously unsuitable.

(3) The following species are the ones most commonly used in airplane construction in the United States: Spruce, Douglas fir, white pine, ash, walnut, birch, oak, hickory, mahogany, and yellow poplar.

(4) Metal can be used in place of wood for any airplane part. In Europe airplanes built wholly or in part of metal have been constructed in large numbers ever since 1915. Most of the German war-planes were of metal. In the United States, however, nearly all of the 13,000

airplanes built during the war were of wood, few metal planes being developed until 1919 or 1920. Early metal construction followed closely the accepted designs for wooden airplanes; recent metal construction leans toward the bridge building art.

(5) Steel, brass, and duralumin, an alloy of steel and aluminum, are the only metals extensively used in airplane construction.

(6) Nearly all propellers are made of wood.

(7) Wood is the best material for experimental design and construction.

(8) For building airplanes in small numbers, wood is preferable in every way. For quantity production, metal is doubtless superior.

SUGGESTED APPLICATIONS OF STATISTICAL METHODS IN FORESTRY PRACTICE (1) (2)

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A large proportion of the work connected with the practice of forestry is concerned with the collection of statistics; statistics of stand of timber or statistics of rate of growth, for example. In work of this character, the figures secured are intended to represent a larger group of measurements, or in some cases, an infinitely large group of measurements, from which the measurements examined are drawn; that is, the work is based on samples drawn from the material under examination. This work is identical in character with work done in other biological sciences and in the field of investigation to which statistical methods are mainly applied, viz; investigation of the social organism. The following are examples of the uses of statistical methods in the practice of forestry:

(a) In an estimate of timber, based on a partial tally, it is possible to determine the relative degree of accuracy obtained by different percentage tallies over a given area.

(b) In the prediction of yield based on increment borings, or in the application of volume tables based on form class, it is possible to determine the number of measurements necessary to secure a given degree of accuracy in the average required.

(c) If a comparison is made of two averages, such as a comparison of rate of growth in one plantation with rate of growth in another, it is possible to determine whether the difference evident is a real difference or whether the difference is due merely to some chance in the selection of the sample measuremnts on which the two averages are based.

The following discussion is an attempt to show the application of these methods to the prediction of yield based on measurements of contemporary diameter growth.

The use of increment borings as a basis for determination of volume increment is general. One method of calculating contemporary volume increment from Pressler borings, based on a determination of the num-

ber of years required by the various inch classes represented to grow from the next lower inch class, is described in an article by McCarthy and Robertson, "Volume increment on cut-over pulpwood lands" (3).

The figures for rate of growth in the various inch classes are arithmetic averages, based on a number of sample measurements of the number of annual rings in the last half inch of radius, each average being for one particular diameter class in a defined type. In any diameter class, the number of rings in the last half inch, termed the "variable," will vary in the trees examined and the different values of the variable will group themselves round the average. The manner in which the values of the variable group themselves is termed the frequency distribution or dispersion. This dispersion can be measured and expressed mathematically. The measure of dispersion commonly used is the standard deviation, which is the square root of the mean of the squares of the deviations of the different measurements from the arithmetic average of the group of measurements examined.

Let s = Standard deviation
Σ = Sum of
d = deviation of any one measurement from the arithmetic average
d_0 = difference between arbitrary origin and arithmetic average
n = number of measurements

$$s = \pm \sqrt{\frac{\Sigma d^2}{n-1} - d_0^2}$$

Examples of the calculation of the standard deviation are shown in Tables 1 and 12.

The value of any average, based on sample measurements, will approximate more or less closely to the true average for the material examined. The degree with which the observed value approximates to the true average will vary with the character of the material from which the samples are drawn. The standard error may be used as a measure of the precision of an average; the less the standard error, the greater the precision. Using the same notation as above, and using S for for standard error,

$$S = \frac{s}{\sqrt{n}}$$

It will be seen that the less the standard deviation (that is, the less the variation in individual measurements) and the greater the number of

measurements, the less the standard error and the greater the precision, which is, of course, what might be expected.

In terms of the matter under discussion, for a required measure of accuracy or precision in the average rate of growth, more sample measurements are necessary in irregular than in regular stands, and the application of statistical methods allows the calculation of the number of samples required for the measure of precision desired.

It has been suggested that 100 borings are required for each inch class in each species, type and condition. On this basis, with three species, two types, cut-over and virgin conditions and eight inch classes, about 10,000 borings would be required. If we consider $85 per 1,000 as the cost of taking Pressler borings, the total cost of taking borings in connection with any investigation of growth, under the conditions given, would be about $850. It seems clear therefore, that if we can show that sufficiently accurate results may be obtained by fewer measurements, a substantial saving of money may be effected.

The figures used for purposes of illustration are those collected in connection with an investigation of the rate of growth of balsam fir in the mixed type, on cut-over lands, in the Tomogonops River district, New Brunswick (*4*).

Borings were made on about 500 balsam, distributed throughout the inch classes represented. From the records it was not possible to determine the system of selection of trees for borings. While it appears as if a larger proportion of five inch trees may have been selected than from other diameter classes, I will assume, for the purpose of this example, that the number of trees bored in each inch class represents the distribution of inch classes in the forest.

At each boring, the number of rings in the last half inch of radius was determined. This is the variable under examination, and this will be referred to hereunder as "rings in last half inch," or "years to grow one inch in diameter."

Table 1 shows the dispersion of the variable in trees in the 5-inch class. The mean is found to be 16.4 and the standard deviation ± 6.0. It will be noted that the dispersion is very regular on both sides of the average, except for the trees of very slow growth, 29 "rings in last half inch" and more. Tables 2 to 7 inclusive, showing the frequency distribution of the variable in the inch classes 6 to 11 inclusive are omitted (*5*). Table 8 summarizes the averages, standard deviation and number of trees for each inch class.

It can be shown that, in a normal frequency distribution, the number of deviations beyond a certain multiple of the standard deviation is very small and it becomes a question, in examination of any frequency distribution, whether the theoretical probability of such a deviation occurring is so small that we would be justified in rejecting from our average the measurement of the variable corresponding to that deviation.

Roughly, any deviation that exceeds three times the standard deviation is outside the limit of theoretical probability, and the corresponding measurement of the variable would be rejected. If we consider Table 1, we find that the deviation of the variable, 44 rings in last half inch, is considerably more than three times the standard deviation; if this measurement be rejected, the standard deviation becomes ± 5.5 and the deviation of the variable, 34 rings in the last half inch, is well over three times the standard deviation; if this measurement in turn be rejected, the standard deviation becomes ± 5.4 and the average 16.0 years. No further deviations exceed three times the standard deviation so that these values of the average and standard deviation may be taken as giving as close an approximation to the true values of the average and standard deviation of the 5-inch trees as is possible with the material available. The same method may be followed in examination of the frequency distributions of the other inch classes. Table 9 shows the values of the average and standard deviation and the number of trees, on the basis of this correction, two measurements being rejected in the 6-inch class and two in the 9-inch class.

In using the standard deviation as a basis for rejection of measurements we assume that the frequency distribution is normal. In the 5-inch and 6-inch classes, the distribution appears to be not altogether normal. If this abnormality is representative of the condition in the forest we are hardly justified in rejecting the measurements as noted above. In the 9-inch class it seems fairly clear that two trees should be rejected.

Another limitation of the use of the standard deviation as a measure of precision, or as a standard for rejection of doubtful measurements, lies in the necessity of ensuring that the value of the standard deviation used approximates to the true value of the standard deviation for the material examined. For this reason it is better, if there are only a small number of trees in the frequency distribution examined, to use an empirical figure for the standard deviation. In this case, no

other work on this class of material is available at present, so that we must use the figures in Table 8 or Table 9, to provide the measure of precision of the averages.

Whether we reject certain measurements or not and even though our calculation of the standard deviation may be based on too few trees in the case of some inch classes, the figures for standard deviation give us a satisfactory idea of the precision of our averages in this case. It has been pointed out that the lower the standard deviation the greater the precision so that if we take a figure for the standard deviation that is, if anything on the large side, we will have a conservative estimate of the precision.

On the basis of the figures in Tables 8 and 9 we are justified in setting the figures for standard deviation of the inch classes 7 to 11 at ± 4.5, for the 6-inch class at ± 7.0, for the 5-inch class at ± 6.0.

It has been shown that the standard deviation of the average of a number of measurements (the standard error), is equivalent to the standard deviation divided by the square root of the number of measurements. So that the standard error for the average number of rings in the last half inch of radius in the 5-inch class is ± 6 divided by square root of $72 = \pm 0.7$. With a hundred trees the standard error would be ± 0.6 and with 50 trees ± 0.9.

We know that, in a series of samples taken from the same material, the observed results from each sample cannot be expected to be the same. These fluctuating averages will form a frequency group, and the standard error is an expression of the dispersion of the various averages. It has been indicated already that any deviations in a normal frequency distribution, exceeding three times the standard deviation are considered outside the limits of theoretical probability. This applies to a frequency group made up of averages and we may consider that any deviation of an average greater than three times the standard error is highly improbable; we can consequently consider that any average we obtain is not more than three times the standard error from the true average from the material examined, and we can set the limit of error in any average as three times the standard error.

In this connection it is important to bear in mind that, while three times the standard error is taken as the limit of error of an average, we are unlikely to have any errors greater than twice the standard error. A table of chances of any error exceeding a given multiple of the standard error can be built up. The chance of an error exceeding

three times the standard error is 1 in 370, two and a half times the standard error 1 in 80 and twice the standard error 1 in 22.

In the case under discussion, we can show the number of measurements required for a given standard error, and so a given limit of error. These figures are shown in Table 10.

The calculation of the number of measurements required is made from the formula $n = \left\{ \frac{s}{S} \right\}^2$

where n = number of measurements
s = standard deviation
S = standard error.

If the limit of error is to be 2 years, the standard error must not exceed one-third of this, or 0.67; in the 5-inch class the standard deviation is $\pm$ 6.0 and the number of trees required is consequently,

$$n = \left\{ \frac{6.0}{.67} \right\}^2 = 80$$

If we assume that it is necessary to separate the rate of growth for each inch class, it would appear that, for 7 inch classes, about 400 trees are required to limit the maximum error in the average for any one inch class to two years, and about 1,600 trees to secure a limit of error of one year.

This brings us to a consideration of the requisite accuracy in our averages of number of years to grow one inch in diameter.

The prediction of yield is intended to cover ten years; that is, we predict the growth in each inch class over the ten-year period. Tables 8 and 9 show the years to grow one inch in diameter. Table 11 shows averages from Table 8 and diameter growth over the ten year period from Table 8.

It can readily be shown that, for the rates of growth represented, a difference of three years in the average number of years to grow one inch makes a difference in diameter growth of about one-sixth of an inch, that differences of two years and one year are equivalent to differences of one tenth and one twentieth of an inch respectively. In the different diameter classes, these differences in diameter growth cause differences in predicted volume at the end of the period of about 5 per cent, 3 per cent, and 1.5 per cent, respectively. When we consider that these errors are compensating throughout the inch classes represented, the error in the whole estimate on this account may be

expected to be very small; and since other errors in the prediction are undoubtedly very large, such, for example, as prediction of mortality over the ten year period, the accuracy in the total estimate that we obtain with a limit of error of three years in each inch class average may be considered as sufficient, and may indeed be still so precise as to be out of all proportion to the accuracy of other parts of the estimate.

If this is the case, it at once appears that there is hardly any necessity for separating the rates of growth of the different inch classes, since the differences between the averages of the different inch classes are, for the inch classes mainly represented, less than, or at the extremes not very much greater than, the allowable error in each average.

Table 12 shows the frequency distribution of the variable for all the material examined, including a number of trees in higher inch classes, not included in Tables 1 to 7. The average and standard deviation for all the material are 14.7 years and ±5.5 years respectively. If we reject those magnitudes of the variable with a deviation greater than three times the standard deviation, the average and standard deviation are 14.1 years and ±4.4 years respectively.

It will be seen at once that in either case, the diameter growth over the ten-year period may be taken as 0.7 inches.

For inch classes 7, 8, and 9, this rate of diameter growth is the same as for each inch class taken separately; for inch classes 5 and 6, this rate of growth is higher and for inch classes 10 and 11, it is lower. It can readily be shown that the calculation of the increment percent for the material under consideration gives practically the same result whichever figures for rate of diameter growth are used, the increment per cents for the ten-year period being as under:

Using rate for growth for each diameter class, from Table 11, increment is 1.9 per cent.

Using general rate of growth of 0.7 inches over the ten-year period, increment is 2.0 per cent.

This seems to bear out the suggestion that for a prediction of yield over a ten-year period, in this class of material, it is hardly necessary to determine the rate of growth of individual inch classes, but that a general rate of growth may give sufficiently accurate results.

This brings us to a consideration of the number of measurements

necessary to give a sufficiently accurate average rate of growth for the whole material.

Table 12 shows that the standard deviation of the number of years to grow 1 inch in diameter is not greater than ± 5.5. If we reject 18 of the 533 measurements, whose deviations are outside the theoretical limit of probability, the standard deviation is ± 4.4.

A further limitation of the use of the standard error as a measure of precision lies in the necessity of certain conditions being fulfilled. The condition that is broken in this case is that the individuals in the sample are selected from different groups of measurements having different growth rates; some from 5-inch trees, some from 6-inch trees, and so on. However, the effect of this is, in this case, very small, and in any event the figure for standard deviation is, if anything, higher than the true value of the standard deviation, and gives therefore a conservative measure of the precision of the average.

Taking the standard deviation of 533 measurements, the standard deviation of the average (the standard error), is $\pm 5.5 + \sqrt{533} = \pm .24$ years. Three times this, or $\pm .72$ years, should include any error we might have in determining average number of years to grow one inch, from any 500 measurements in this material. It has already been shown that an error of three years in the average number of years to grow the last inch, involves an error in total predicted volume, for material of this class, of not more than 5 per cent and that an error of two years involves an error of only 3 per cent. In view of the inaccuracies of other parts of the estimate, it hardly seems necessary to attempt to get any closer accuracy in the predicted volume than three per cent or so. On this basis, if we set a limit of error of 2 years for our average number of years to grow one inch in diameter, we require, with a standard deviation of ± 5.5, measurement of number of rings in last half inch, on 67 trees only. Measurements on 100 trees will give us a limit of error of $\pm 5.5 \div \sqrt{100} \times 3$, or ± 1.6 years. This can be tested from the measurements in Table 12. These figures can be separated into five groups, the measurements in the original notes being allotted in turn to one or other of the five groups. If the original measurements were representative the measurements in each group will be representative.

Table 13 shows the figures for each group, with average and standard deviation of all the measurements, also average and standard deviation for the measurements exclusive of those whose deviations exceed

three times the standard deviation; each average is based on about 100 measurements. It will be noted that in no case does the average of a group differ from the average of all the measurements by as much as one year. It has been shown that the limit of error for an average of 100 measurements is about ± 1.6, so the averages of these five groups come well within the allowable limit of error. It will be noted also that the figures for number of years to grow one inch in this table, when expressed as diameter growth over the ten-year period, all give the same result, viz; 0.7 inches.

In the investigation of growth rate from which the above example was drawn, it was intended to cover growth rate of balsam, white spruce and black spruce in softwood type, in mixed type, and on virgin and cut-over lands. If 100 Pressler borings are required on each inch class, about 800 borings will be required for each species, type and condition, with a total cost for the investigation of somewhere about $850. It has been shown for the balsam, mixed type, on cut-over lands, that measurement of rate of growth on 60 or 70 representative, or mechanically selected, trees will give a sufficiently accurate average rate of growth for prediction of yield. If the same condition is found to prevail in the other species, types and conditions, the total number of Pressler borings required will be about 850, instead of 10,000. If the borings are made in the course of a strip survey, the unit cost will be about the same for a small number as for a large number of borings and our cost for borings would be reduced, in this case, from $850 to about $100.

It will be noted that we can not at present make any estimate of the number of borings required for any species or type without carrying out a preliminary investigation such as that outlined above. The main requirement is a reliable figure for the standard deviation. This may involve the making of a larger number of borings than are required for actual prediction of yield. But once the work is done for a given species or type, it would seem hardly necessary to repeat this work for any future predictions of yield in that species and type. It seems reasonable to suppose that, as the results of work of this nature accumulate, empirical figures for standard deviation may be applied to different species and types. If this is the case, it will be possible to determine at once the number of borings required to give any required degree of accuracy.

TABLE 1.—*Growth Rate Dispersion. Balsam Fir, Mixed Type, Cutover Lands. Tomogonops District, N. B. 5 Inches D. B. H.*

Rings in last ½ inch radius	Frequency "n"	Deviations from origin 16				
		d+	(d+) × n	d—	(d—) × n	d² × n
44	1	28	28	....	....	784
34	1	18	18	....	....	324
33	....	....	....	....	....	....
32	1	16	16	....	....	256
31	4	15	60	....	....	900
30	1	14	14	....	....	196
29	2	13	26	....	....	338
28	....	....	....	....	....	....
27	....	....	....	....	....	....
26	1	10	10	....	....	100
25	1	9	9	....	....	81
24	1	8	8	....	....	64
23	5	7	35	....	....	245
22	2	6	12	....	....	72
21	6	5	30	....	....	150
20	6	4	24	....	....	96
19	7	3	21	....	....	63
18	11	2	22	....	....	44
17	8	1	8	....	....	8
16	10	....	....	....	....	....
15	8	....	....	1	8	8
14	20	....	....	2	40	80
13	15	....	....	3	45	135
12	12	....	....	4	48	192
11	4	....	....	5	20	100
10	6	....	....	6	36	216
9	6	....	....	7	42	294
8	4	....	....	8	32	256
7	1	....	....	9	9	81
6	1	....	....	10	10	100
	145	....	341	....	290	5,183

$$\text{Mean} = 16 + \frac{341-290}{145} = 16.4$$

Standard deviation

$$= \pm \sqrt{\frac{5183}{144} - .4^2}$$
$$= \pm 6.0$$

Rejecting measurement 44:—

$$\text{mean} = 16 + \frac{313-290}{144} = 16.2$$

Standard deviation

$$= \pm \sqrt{\frac{4399}{143} - .2^2}$$
$$= \pm 5.5$$

Rejecting measurement 34:—

$$\text{mean} = 16 + \frac{295-290}{143} = 16.0$$

Standard Deviation

$$= \pm \sqrt{\frac{4075}{142}}$$
$$= \pm 5.4$$

REFERENCES IN TEXT

(1) "The Use of Statistical Methods in Forest Investigative Work." W. G. Wright. Memorandum circulated privately by the Dominion Forest Service, Ottawa.
(2) "An Introduction to the Theory of Statistics," fifth edition, Yule.
(3) "Volume Increment on Cut-over Pulpwood Lands," McCarthy and Robertson, JOURNAL OF FORESTRY, October, 1921.
(4) The writer is indebted to the Acting Director of Forestry, Dominion Forest Service, for permission to use this material for purposes of illustration.
(5) The inclusion of Tables 2 to 7, inclusive, is not necessary for the argument, these tables being identical in form with Table 1.

TABLE 8.—*Summary. Diameter Growth at Breast Height Expressed as Rings in Last Half Inch of Radius or Number of Years to Grow One Inch. Various Inch Classes. Balsam Fir, Mixed Type, Cut-over. Tomogonops District, N. B. Including All Measurements on These Inch Classes.*

D. b. h.	Average rings in last half inch radius	Standard deviation	Number of trees
5	16.4	6.0	145
6	16.9	6.6	74
7	14.0	4.3	108
8	13.7	4.0	80
9	13.4	5.2	53
10	12.6	4.3	33
11	11.4	3.1	12
			505

TABLE 9.—*Summary. Diameter Growth Rate at Breast Height Expressed as Rings in Last Half Inch of Radius of Number of Years to Grow One Inch. Various Inch Classes. Balsam Fir, Mixed Type, Cut-over. Tomogonops District. N. B. Including Only Those Measurements in These Inch Classes Within The Limits of the Theoretical Probability.*

D. b. h.	Average rings in last half inch radius	Standard deviation	Number of trees
5	16.0	5.4	143
6	16 3	5.8	72
7	14.0	4.3	108
8	13.7	4.0	80
9	12.8	4.0	51
10	12.6	4.3	33
11	11.4	3.1	12
			499

TABLE 10.—*Contemporary Growth Rate at Breast Height Expressed as Number of Years to Grow One Inch in Diameter. Balsam Fir, Mixed Type, Cut-over Lands. Tomogonops District, N. B.*

Inch class	Standard deviation	Number of measurements required for given limit of error in the average. Limit of error		
		3 years	2 years	1 year
5	6.0	36	80	320
6	7.0	50	110	440
7	4.5	20	45	180
8	4.5	20	45	180
9	4.5	20	45	180
10	4.5	20	45	180
11	4.5	20	45	180
		186	415	1,660

TABLE 11.—*Contemporary Growth Rate at Breast Height Expressed as Growth in Diameter Over the Ten-Year Period. Balsam Fir, Mixed Type, Cut-over Lands. Tomogonops District, N. B.*

Inch class	Years to grow 1 inch in diameter. From Table 8.	Growth in diameter over the ten-year period. Corresponding to averages in Table 8
		Inches
5	16.4	.6
6	17.0	.6
7	14.0	.7
8	13.7	.7
9	13.4	.7
10	12.6	.8
11	11.4	.9

TABLE 12.—*Growth Rate Dispersion. Balsam Fir, Mixed Type, Cut-over Lands. Tomogonops District, N. B. All Inch Classes.*

Rings in last ½ inch radius	Frequency "n"	Derivations from origin 14				
		d+	(d+) × n	d—	(d—) × n	d² × n
44	1	30	30	....	....	900
38	1	24	24	....	....	576
36	1	22	22	....	....	484
35	1	21	21	....	....	441
34	2	20	40	....	....	800
33	2	19	38	....	....	722
32	1	18	18	....	....	324
31	4	17	68	....	....	1,156
30	2	16	32	....	....	512
29	2	15	30	....	....	450
28	1	14	14	....	....	196
27	....	....	....	....	....	....
26	5	12	60	....	....	720
25	3	11	33	....	....	363
24	7	10	70	....	....	700
23	8	9	727	....	....	648
22	11	8	88	....	....	704
21	12	7	84	....	....	588
20	20	6	120	....	....	720
19	20	5	100	....	....	500
18	25	4	100	....	....	400
17	37	3	111	....	....	333
16	34	2	68	....	....	136
15	31	1	31	....	....	31
14	48	....	....	....	....	....
13	41	....	....	1	41	41
12	41	....	....	2	82	164
11	49	....	....	3	147	448
10	47	....	....	4	188	752
9	34	....	....	5	170	850
8	28	....	....	6	168	1,008
7	10	....	....	7	70	490
6	4	....	....	8	32	256
....	533	....	1,274	....	898	16,406

$$\text{Mean} = 14 + \frac{1274-898}{533} = 14.7$$

Standard deviation

$$= \pm\sqrt{\frac{16406}{532} - 7^2}$$

$$= \pm 5.5$$

Rejecting measurements 31 and over:

$$\text{mean} = 14 + \frac{1013-898}{520} = 14.2$$

Standard deviation

$$= \pm\sqrt{\frac{11003}{519} - .2^2}$$

$$= \pm 4.6$$

Rejecting measurements 28 and over:

$$\text{mean} = 14 + \frac{937-898}{515} = 14.1$$

Standard deviation

$$= \pm\sqrt{\frac{9845}{514} - 2.1^2}$$

$$= \pm 4.4$$

TABLE 13.—*Growth Rate Dispersion. Balsam Fir, Mixed Type, Cut-over Land. Tomogonops District, N. B. All Inch Classes Separated Into Five Groups.*

Rings in last ½ inch radius	Group 1	Group 2	Group 3	Group 4	Group 5
44	......	......	......	......	1
38	......	......	......	1	......
36	......	1	......	......	......
35	......	1	......	......	......
34	1	......	1	......	......
33	......	......	1	1	......
32	......	......	......	......	1
31	1	2	......	1	......
30	......	......	1	......	1
29	......	......	1	1	......
28	......	......	......	......	1
27	......	......	......	......	......
26	2	1	......	......	2
25	1	......	1	......	1
24	......	3	3	1	......
23	2	1	......	2	3
22	1	5	2	2	1
21	2	4	2	......	4
20	5	4	4	4	3
19	3	2	3	6	6
18	6	5	3	5	6
17	6	8	9	6	8
16	7	8	5	10	4
15	9	3	8	7	4
14	9	11	10	9	9
13	10	8	10	8	5
12	8	11	7	11	4
11	9	5	12	12	11
10	11	10	7	6	13
9	4	4	8	6	12
8	6	8	4	6	4
7	4	1	3	......	2
6	1	1	1	1	......
No. of trees	108	107	106	106	106
Mean	14.3	15.2	14.5	14.7	14.8
Standard deviation	±5.0	±5.8	±5.4	±5.4	±6.0
After rejecting doubtful measurement—					
Mean	14.0	14.4	13.9	14.0	14.2
Standard deviation	±4.4	±4.6	±4.3	±4.0	±4.9

COMPARATIVE INCREASE IN VOLUME OF ARTIFICIALLY AND NATURALLY THINNED STANDS[1]

By E. J. Hanzlik

Of special interest to foresters and timber owners are figures indicating the rates of growth of stands in volume which have been treated by different methods of thinnings. It is especially of importance to know whether there is any appreciably increased yield due to artificial thinnings over naturally thinned stands and whether or not this increased yield (if there be any) is due to a combination of the thinned material plus increased growth in the remaining stand, and the proportion played by each.

A series of thinning experiments in a stand of planted Norway spruce (*Picea abies-excelsa*) in the southern part of Sweden instituted by the Swedish Forest Research Station in 1906 in Dalby kronopark (Crown forest) showing a comparison for different grades of low-thinnings give some very interesting figures. Four sample plots, each 0.6 acres in area, in addition to a border zone, were laid out, No. 1 natural thinning, No. 2 a light low thinning, No. 3 a heavy low thinning, and No. 4 in 1906 and 1911 a heavy low thinning and extra heavy in 1916 and 1920.

Summarizing the data presented in the report of the Station, the comparative volume increases in the remaining stand are as given in Table 1.

The facts brought out in Table 1 are that the stand left to itself, Plot 1, has increased in volume 91 per cent in the period from 1906 to 1920, while the thinned stands, considering only the volumes left after thinnings have been made, have increased at a lesser rate, namely, 72, 63 and 27 per cent depending upon the intensity of the thinnings.

Table 2 gives the comparative increases in the total production of the plots (thinned material plus the volume remaining after thinning), these data indicating that the more heavily thinned plots are making the greatest volume production.

[1] Compiled from report by Swedish Forest Research Station, "Beskrivning av Skogsförsöksanstaltens Försöksytor i Skåne;" av Gunnar Schotte.

TABLE 1.—*Comparison of Volume Increase in Artificially and Naturally Thinned Stands Norway Spruce (P. Abies-Excelsa) Dalby Kronopark, Skåne, Sweden.*

[For Remaining Stand, Exclusive of Thinnings]

Age of stand, years	Plot 1.—Natural thinning			Plot 2.—Light low thinning			Plot 3.—Heavy low thinning			Plot 4.—Heavy and extra heavy low thinning		
	Thinning, per cent[1]	Cu. ft. per acre after thinning	Per cent increase in volume	Thinning, per cent	Cu. ft. per acre after thinning	Per cent increase in volume	Thinning, per cent	Cu. ft. per acre after thinning	Per cent increase in volume	Thinning, per cent	Cu. ft. per acre after thinning	Per cent increase in volume
(1906) 31	4.7	3,630	....	5.6	3,450	....	15.4	3,310	....	11.3	3,290	....
37	2.3	5,360	49	3.6	5,040	46	8.5	4,780	45	5.7	4,820	46
42	2.0	6,820	76	7.6	5,750	67	13.4	5,290	60	25.4	4,550	38
(1920) 46	1.9	6,950	91	6.3	5,840	72	14.5	5,390	63	25.1	4,180	27

[1] Dead and dying material taken out only.

TABLE 2.—*Comparison of Volume Increase in Thinned Stands—Total Production of Material, Inclusive of Thinnings.*

Age of stand, years	Plot 1.—Natural thinning			Plot 2.—Light low thinning			Plot 3.—Heavy low thinning			Plot 4.—Heavy and extra heavy low thinning		
	Thinning, per cent	Cu. ft. per acre, total production	Per cent increase in volume	Thinning, per cent	Cu. ft. per acre, total production	Per cent increase in volume	Thinning, per cent	Cu. ft. per acre, total production	Per cent increase in volume	Thinning, per cent	Cu. ft. per acre, total production	Per cent increase in volume
(1906) 31	4.7	3,630	....	5.6	3,450	....	15.4	3,310	....	11.3	3,290	....
37	5.4	5,660	56	7.2	5,420	57	18.0	5,820	59	12.8	5,530	68
42	6.4	6,820	88	13.0	6,600	91	26.1	7,150	116	33.2	6,810	110
(1920) 46	7.5	7,520	107	17.5	7,190	108	34.0	8,180	147	46.7	7,840	135

NOTE.—Volume in 1906 (31 years old) is that of the remaining stand (exclusive of thinnings in that year). "Thinning per cent" in above table figured on total thinnings and total production at the age when thinnings were made.

Table 2, comparing results with Table 1, shows conclusively that the heavier thinned plots, considering both the thinned material and the volume of the remaining stand, have a volume production for the 15-year period about 30 per cent and 40 per cent greater than the unthinned and lightly-thinned plots during the same period. The importance of the thinnings is realized when it is seen that of the total production, 34 per cent and 46.7 per cent are obtained from the thinned material on the heavier thinned plots (No. 3 and No. 4) while on the unthinned plot (No. 1) only 7.5 per cent is due to trees dying out, and on plot No. 2 (lightly thinned) 17.5 per cent is due to thinnings.

A STUDY OF COMPARATIVE HEIGHT GROWTH OF SIX PLANTED SPECIES

By Harold Cahill Belyea

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It has often been asked: How quickly do planted forests grow? How soon can we expect results if we do plant? In answer to the above queries the following brief study is submitted. It is the result of a series of field measurements taken on the plantations of the Great Bear Springs Water Company near Fulton, N. Y. The plantations of the Great Bear Springs Company present some of the finest results of extensive tree planting found anywhere within the State and there is presented here an exceedingly large variety of species covering a considerable range of site and soil conditions.

The plantations of the Great Bear Springs Water Company were established during the years 1908 to 1910. Their purpose was to protect and conserve both the purity and flow of valuable springs of drinking water. A variety of species were used, the results of the planting of six of which are recorded here. Generally the usual planting distance of 6 feet, in rows 6 feet apart was employed. Supplementary planting operations were carried out the year following the initial planting in order to fill in the failures. No further silvicultural operations designed either to protect or assist the plantations were undertaken.

In the late fall of 1922 and early winter of 1923 a series of measurements were made on these plantations for the purpose of getting figures of annual and current height growth. These data, in so far as they affect six of the plant species—white pine, red pine, western yellow pine, Scotch pine, Norway spruce, and Siberian larch are presented in Table 1. These figures represent averages rather than extremes either of minimum or maximum height growth. The figures for each year's height growth is fixed for April 30 of the corresponding year, that date corresponding approximately in this latitude to the beginning of the growing season.

TABLE 1.—*Yearly Attainment of Height Growth in Feet for Six Planted Species, Great Bear Springs, Oswego County, N. Y. Site Quality I.*

Date to which height growth data applies	Total height of the average tree in feet					
	White pine, average of 750 trees	Red pine, average of 494 trees	Scotch pine, average of 750 trees	Western yellow pine, average of 494 trees	Norway spruce, average (curved) 740 trees	Siberian larch, average (curved) 300 trees
April 30, 1909......	0.46	0.36	0.50	0.22	0.80	0.75
April 30, 1910......	0.66	0.56	1.30	0.42	1.00	1.00
April 30, 1911......	1.04	0.76	2.14	0.62	2.50	3.00
April 30, 1912......	1.80	1.30	3.32	1.10	4.60	5.00
April 30, 1913......	2.95	2.10	4.72	1.64	6.80	7.10
April 30, 1914......	4.23	2.92	6.56	2.27	10.00	10.20
April 30, 1915......	5.70	3.82	8.92	2.97	13.20	13.90
April 30, 1916......	7.46	5.20	10.96	3.87	15.00	15.60
April 30, 1917......	9.28	7.28	13.34	5.26	16.60	17.10
April 30, 1918......	10.84	9.04	15.51	6.33	18.00	18.50
April 30, 1919......	12.50	11.05	18.03	7.74	19.30	19.80
April 30, 1920......	13.90	13.03	20.40	9.26	20.60	21.00
April 30, 1921......	15.26	14.95	22.40	10.66	21.70	22.15
April 30, 1922......	16.58	16.83	24.34	12.02	22.75	23.10
April 30, 1923......	17.88	18.63	26.24	13.32	23.50	24.03

From these data several conclusions may be drawn:

1. Three species, Scotch pine, Norway spruce, and Siberian larch, began to develop very early and have surpassed all others in their total and yearly height growths. Any one or all of these three species would be desirable for planting in places where it is desirable to show rapid progress.

2. It is to be pointed out that only average figures were used. While there are in the Great Bear Springs as large figures for total height of the larch as 43 feet and for Scotch pine and Norway spruce, 32 and 33 feet, the use of such figures has been considered undesirable in view of the danger of their leading to rather extremely optimistic conclusions regarding the growth of these species in plantations.

3. The general use of the larch is not advocated. Rather advantageous soil and moisture conditions at Great Bear Springs have favored its rapid development. Here there is a rather light porous sandy loam soil with water table close to the surface layers of the soil. It is not believed that larch will do well in a clay soil nor in one where there is a considerable amount of loose stone or boulders. Furthermore, this development has been made during a period of freedom from insect pests, notably the larch saw fly. Just how susceptible the Asiatic

species of tree will be to the American species of insect we do not know. And until we do it might be advisable to be conservative in advising the general use of the tree.

4. Based on the results submitted here, a tentative conclusion would be that the planting of western yellow pine is not advisable in the Northeast. It is believed that northern New York and eastern Canada is so far outside of the natural range of this species that any success in its use is extremely doubtful. This conclusion already seems to be borne out in the Great Bear Springs plantation where in only 14 years the height growth of western yellow pine has already dropped far behind that of the other five species studied.

5. By far the finest appearing tree in the Great Bear Springs plantation is the red pine (*P. resinosa*). Its progress has been steady and consistently rapid. Its general good health, its sturdy vigorous appearance, its freedom from insect and fungus pests and its consistent growth all commend this tree to an even more general use in planting, at least in the Northeast, than it has had.

6. It will be observed from the table that at first our native eastern white pine showed a more rapid growth and in 1918 surpassed the red pine. In the last 7 years this comparative rating has been reversed and the red pine is slightly taller than the white pine. It should be pointed out that the white pine in this plantation is just recovering from a severe white pine weevil infestation, in which upwards of 73 per cent of the trees show infections. The inevitable result of a heavy weevil infection is to slow up height growth somewhat. This in part, it is believed, accounts for the retardation of the height growth of the white pine.

BENEFITS OF READJUSTED FOREST TAXATION

By Fred Vibert

Editor of Pine Knot, Cloquet, Minn.

From 37 years' experience in northeastern Minnesota, I am of the opinion that to develop our cut-over lands successfully forest products must be considered one of the farmer's crops. This was brought home to us very forcibly after the disastrous forest fire of 1918. Previous to this the manufacturer, business man, and home owner in the city of Cloquet was going along very contentedly; in fact in a rut. The factories and mills were running steadily, the surrounding land was being opened up, new settlers coming in, and old ones clearing additional land. The fire cleaned us out and left the surrounding country a burned-over waste.

During 1919 we were busy rebuilding; the farmers were given portable mills to salvage their burnt timber and they were all rebuilding; but in 1920 some of them were borrowing money, not for improvements, but to carry them along, or asking the merchants for credit, and in 1921 more were doing the same thing and some were listing their places for sale.

Upon investigating we found the trouble was that their main crop—forest products—had been removed, and upon further investigation we found that forest products had heretofore been giving them from 30 to 50 per cent of their income. It was then brought home to us very forcibly that the new settler needed and must have a forest crop to harvest in the winter months in order to eventually become a successful farmer.

We are all complaining about high taxes and the popular cry today is "lower taxes." The National Congress and State legislatures are struggling with the problem, but let us consider what can be done at home and some of the reasons for high taxes in the rural communities.

A prospective settler is taken out by a land agent and shown a piece of land, and in most cases it is as represented, but no consideration is given to the surrounding lands; it may be several miles to another good piece of land where another farmer is located, or where one may locate in the future.

Let us take the smallest unit—a township organization and school district, generally comprising a congressional township—which contains approximately 24,000 acres, usually part good agricultural land and part not suited for agriculture. As an example let us study one which is half and half, and there are many such in northeastern Minnesota. The one-half or 12,000 acres is four-fifths good agricultural land and will make 96 farms of 100 acres each; the other half is four-fifths non-agricultural and will make 24 farms of 100 acres each. After the timber is cut there is only the land and improvements to assess and the non-agricultural land will eventually be, if not now, on the delinquent tax list. Therefore I claim that the 96 farmers on the good one-half are paying in local taxes for the deficit of the 24 scattered farmers on the poor one-half. The miles of road to build and maintain, the number of school busses or school houses are approximately the same for the scattering 24 as for the consolidated 96.

If the 12,000 acres were classified as non-agricultural land and used for a forest crop because of a readjusted taxation, and an annual land tax of 5 cents per acre for local purposes was paid, then the one-half township classified as agricultural land would receive $600 annually from the forest land.

Foresters tell us that a safe margin to figure for timber growth is one cord per acre a year, using a basis of $3 (which may be high now) for stumpage value, and a yield tax of 8 per cent would give a tax of 24 cents per acre, or a total land and yield tax of 29 cents, amounting to $3,480 from the forested one-half township with no outlay for roads or schools.

In addition to the tax benefit there would be 12,000 cords of forest products to harvest every winter. A conservative estimate would be $4 per cord for cutting and hauling, making a total annual expenditure in the immediate vicinity of $48,000, or an average labor income of $500 for each of the 96 farmers.

But let us follow this forest crop to the manufacturing center. The railroad transportation would average $2.50 per cord, or a total of $30,000 mostly labor cost. The amount of payroll if manufactured into paper would be approximately $180,000; if manufactured into toothpicks, clothes pins, wooden novelties, etc., $300,000; if manufactured into boxes, butter tubs, lard pails, egg cases, etc., $120,000; there are also other uses such as mining timber, lath, bolts, etc., but which I will not take the time to go into at present. This forest product at the

manufacturing center not only makes additional taxable property, but makes a market for the farmer's produce as well.

The farmer has a further interest—the saving in freight on containers for his produce. Wisconsin and Minnesota in 1922 produced about 350 million pounds of butter and it took 70,000 cords of forest products to manufacture the boxes, tubs, cartons, and wrappers required to ship it in.

Any discussion of reforestry always ends in the statement that it is not feasible on account of fire and taxes. The prevention and fighting of forest fires is now being done almost wholly by the States. But the rangers employed by the owners of the 12,000 acres in the example cited would have local co-operation in prevention of forest fires and 96 willing fire fighters, thereby saving money for the taxpayer.

The following is taken from U. S. Forester Greeley's annual report for 1923. He says:

"One of the factors affecting the volume of timber business in the National Forests is the continued western migration of forest industries from the depleted timber regions of the East. Eastern sawmill capital is at present being invested more largely on the Pacific coast than elsewhere, and this is reflected in the sales of timber from the National Forests of that region.

"All sales of timber from the National Forests take into account the sustained yield principle, thus affording a perpetual supply on the sale area. One of the outstanding sales of the year was the Bear Valley unit in Oregon. This sale involves 890,000,000 board feet of timber, and will bring into the United States treasury not less than $2,500,000 during the sale period of 20 years. The management plan under which the sale was made contemplates a continuous supply of from 40,000,000 to 60,000,000 feet annually to one manufacturing center. The capital invested in this sale originated in the Lake States and has moved South and West periodically ever since. So far as a supply of raw material is concerned it will never have to move again."

With readjusted forest taxation and co-operative fire protection we could have a perpetual supply of raw material, thereby keeping capital invested here and in addition save the freight which costs Minnesotans over $11,000,000 annually on outside shipments of lumber.

To sum up:

Every acre green and producing.

An increase in taxable property and reduction in taxes.

Permanent investment of capital in industry.

Individuals co-operating with the States and U. S. Government in racticing reforestry.

Competition in production of raw material and complete utilization n manufacturing.

Increasing and more rapid settlement and improvement of our agri-ultural lands.

These are some of the benefits that will be derived from a system of readjusted forest taxation.

INTEREST RATE AND FORESTRY

By Albert V. S. Pulling

A short time ago I was talking with two of my former students who have been working in the West since the spring of 1920. One of them had some very interesting comments on interest rate. He had recently finished a survey and was asked by an official who was higher in his organization, but who was not a forester, what profit in percentage could be expected from that type of land. He immediately replied that one should get about 2 per cent. The higher official gasped and said that they could not admit, say nothing of publishing, such a figure. The forester said that he gave the figure as snap judgment and that if it appeared impossible, he couldn't help it. But investigation showed that 2 per cent was plenty high enough. The organization, however, juggled and twisted the published report, camouflaging the interest rate, and actually making some statements that were *known* to be inaccurate.

Many things in forestry are hard to compute and a fair interest rate may be hard to establish. Foresters are not now and will not be agreed among themselves for a long time to come on this comparatively small point. I have seen fine land in New Hampshire that will pay a big interest rate, and spruce land in the same State that I am sure has not paid 2 per cent per annum in 50 years. At any rate, it hasn't paid taxes.

In the October, 1922, Journal of Forestry, C. H. Guise wrote an interesting article on the "Rate of Interest as a Factor in the Cost of Growing Timber." In this article one conclusion was drawn that I believe is absolutely wrong, and actually dangerous to the reputation of foresters who must believe in sound economics. That it, that 4 per cent compound interest or 6 per cent annual interest is about what should be expected from the business of growing timber. This may not be too high a rate in many localities, but as a country-wide, or continent-wide, average, it is hard for me to believe. Perhaps the post-war inflation, with its impossibly high lumber prices, could have made such a rate possible if it had continued. But, at the time Mr. Guise wrote, woods wages in eastern Canada were about $30 a month, mills were on half

time, and lumber was being sold at about the cost of production. In spite of the improvement since 1922, profits in lumber do not justify planting unless it is very carefully planned, and the profits from natural regeneration to a private investor are a worse gamble than a New England farm. And even the best organized forests of Europe, with a few notable exceptions, fail to produce anywhere nearly 6 per cent annual interest.

We may also compare the forest crop with the agricultural crop. Roth, on page 28 of "Forest Valuation," states that he doubts if the average farm of the United States actually makes 2 per cent per annum on the investment. From personal farm experience, I doubt it too. Some years the farm earns no interest whatever. When incomes are large, values are also large. An occasional "killing" will net a big return. Farming has improved since Professor Roth compiled those figures in 1916, but we do not know that the improvement is permanent and we do know that since 1916 the farmer has had some of the leanest years during this generation.

An interest rate of 3 per cent may be too high an average in actual practice. Take a concrete example with which I am very familiar. The Province of New Brunswick controls some 7,500,000 acres, more or less, of non-taxable Crown land. This figure is approximate, for the survey is not finished, but we will assume that one-third of this land is non-reproducing burn, bog, water, and other valueless land. This leaves at least 5,000,000 acres. The *gross* income exceeded $1,500,000 one year. The net income was formerly only a few hundred thousand dollars, and now probably doesn't average a million a year. If there are 5,000,000 acres, with a net profit of $1,000,000, the net income is 20 cents an acre per annum. At 6 per cent per annum this land would then be worth $3.33 per acre. A failure, you may say? Distinctly not. The land may be worth several times $3.33 an acre. Again, the University owns nearly 4,000 acres of forest land. We are doing our best with it, but the net income is also pretty close to 20 cents an acre. Of course, these lands are not under intensive management and of course they have been badly abused in the past. But most North American timber-lands have been abused, and mighty few are under intensive management. It is dangerous to prophesy what they will grow until we have really *grown* timber on large areas that will show a substantial profit.

This New Brunswick land and most of the forest lands of the Eastern States should make a net profit of at least a dollar an acre per annum.

It will do it in time. It may do better. But by that time its selling price will advance tremendously. Yet, in spite of seeming contradictions, New Brunswick Crown land pays well in direct and indirect profits. It pays as well as the Crown land of any province. It pays better than the public lands of any State that I know about. The Province is hanging onto it in the hope that it will pay better, and for the indirect benefits derived from all State lands, as well as for direct benefits such as cause certain far-sighted lumber companies to retain their cut-over lands. We believe that we can get at least 3 per cent per annum on the investment in a few years' time. I doubt if we shall get over this amount during the next 50 years. About 3 per cent compounded is the acme of my hopes, unless our financial and economic status becomes much different from what it is at present.

It seems to me that in assuming an interest rate that is too high, failing to get it and proving ourselves wrong, the best interests in forestry are injured. A better way might be to assume a very low rate, and do better if we can. We must attract the investor but we shouldn't gold-brick him. Whether the interest rate is high or low, timber *must* be grown. We are going to grow it and we are going to work for an economic adjustment so that it may be grown at a profit. I am not a calamity howler. We may avert the "timber famine" so long predicted. But we must either assume a low rate of interest in the business of growing timber, and get it, or assume a high rate and get—a loss.

This is written to invite discussion rather than as a long-delayed criticism of the excellent paper referred to, and I shall be very glad to have my present opinion proven as wrong.

FORESTRY AND THE PULP AND PAPER INDUSTRY OF THE NORTHEAST

By B. A. Chandler

To those of us who are used to thinking of forestry in terms of ıtensive silviculture or sustained yield the practice of forestry in he pulp and paper industry will appear to be very extensive and not vorthy of the name. When the local types and their ability to repro-uce themselves are considered the situation appears much better. Vhen the progress made over a period of years and especially the hange in the point of view of the executive in the industry is con-idered the present situation is very encouraging.

If we would understand the situation correctly we must look at t from the standpoint of the industry. We must see the problem s the executive sees it. We must think of it as a fight to keep a upply of wood behind the pulp mill. To the executive in the pulp nd paper industry the forest always has been and always will be a ource of wood. The persistent demand for wood has forced him nd will continue to force him through the various stages of buying arge reserves of timber, of eliminating wastes, and finally to growing vood.

As you all know the first method used to put a supply of wood back of the pulp mill was to buy large reserves of mature timber. After the ıeed for these reserves was realized by the more far-sighted oper-tors it was not long before all the large tracts in the northeastern Jnited States were controlled by individuals, estates, and companies vho realized their value and intended to hold them. The remaining ompanies had to go to Canada for their reserves of mature timber. This resulted in expensive transportation and many other difficulties aused by an international boundary between the mill and its supply of wood.

This policy has been sound except in one respect. The average xecutive has failed to realize that in buying large reserves which vould last his plant from 50 to 100 years he was buying a great deal of mature timber which would die and fall down before he could cut

it. If he has purchased mature timber for a 50-year supply and with the balance of his funds had purchased young stands, with due regard to age classes, he could have obtained much more pulpwood situated nearer his mill.

As the executives saw that the reserves they controlled were not going to last forever they took steps to eliminate wasteful methods of utilization. You are all familiar with the inspection systems which were established to eliminate high stumps, waste in tops, and other forms of logging waste. Many companies have stopped here. Few of them have seemed to realize the tremendous saving that could be made by locating cuttings in the more mature stands and leaving the stands with a large percentage of young growth for later cuttings. The greatest opportunity I have seen for this particular form of saving waste is in the balsam forest of eastern Canada which is made up of even-aged stands of different ages. When a particular slope becomes mature it is blown down very rapidly and the young stand, already started underneath, takes its place. Often young stands which have just reached pulpwood size are being cut in one valley while just over the divide in the next valley mature stands are blowing down. Although this policy would save wood, it would increase present costs. Improvements would have to be maintained until the young stands had matured in addition to the cost of opening up the new stands.

Some companies are going still further and are cutting so as to encourage natural reproduction. Although the systems are very extensive they are giving results.

In New Brunswick there is a woods superintendent who is a real practical forester. He, and his father before him, have worked out an intensive form of management with a simple system of silviculture. They have "blocked" the forest into natural jobber's logging units of various sizes depending upon the topography and other logging conditions. These so called "blocks" correspond very closely to what we call compartments. The cuttings are controlled by diameter limits. The system has produced results because they have gathered around them good jobbers who will cooperate in an intelligent use of the diameter limit.

One New York company has its forester go over every area before it is cut. The forester decides whether the area shall be cut clean, to a diameter limit, to a height limit, or will have to be marked. The

esults are not as satisfactory as they would be if more marking could e done, but it is a step in the right direction.

Some attempts are being made at artificial reproduction, but they are egligible as a solution of the problem of a future supply of wood for ne industry. In fact most of the nurseries being maintained and the lantings being made are for political purposes rather than for a future upply of raw material.

The most vital thing in the whole subject, however, is the point of iew of the executives at the head of the industry. They really deter-nine the policies. To understand their point of view we must first onsider the basic ideas which dominate their thinking. These we will all profit, opportunism, and protection of capital.

We all recognize that profit is fundamental in the business man's hinking. Most of us will admit that it is right that it should be except vhen it interferes with some of our own pet projects.

Opportunism is the instinct of the executive for putting present profits head of future profits. The executive is continually trying to meet he present situation so as to make a profit and trusts that he will be ble to meet the conditions as he finds them tomorrow so as to make profit out of them. He makes hay while the sun shines. A bird in he hand is worth two in the bush.

However, profits can not be made without capital. Capital can not e obtained at a reasonable cost unless it can be shown to be reasonably safe. Thus the necessity of protecting the invested capital is the third fundamental idea which dominates the thinking of the executive in he pulp and paper industry.

The present situation in regard to pulpwood is making the executive n the pulp and paper industry do some serious thinking in regard to the protection of the capital in the industry. As noted above, the sup-plies this side of the Canadian border are nearly all controlled. Ca-nadian public sentiment against shipping raw pulpwood out of Canada is becoming stronger and the embargo has made the executive realize that the time may not be far distant when Canadian lands and timber will be of little value in protecting the invested capital represented by the mill properties in this country. To depreciate this investment on an economic basis instead of the usual physical basis means a decrease in profits. Thus some of the executives are beginning to consider seriously the systematic growing of timber in this country as a means of protecting the capital invested in the industry.

We must not, however, fool ourselves into thinking that this will mean the acceptance of the principle of sustained yield. This must be changed to the principle of a reasonably sustained supply of pulp wood. Regardless of how much it may upset the age classes and the normal forest capital wood will have to be made available during the periods when excesively large profits can be made in the industry. At such time the opportunity for profit outweighs everything else in the mind of the executive. The forester in the industry must also be an opportunist. He will get what reserves he can back of him between these periods of excessive demand. During the periods when his company is making large profits he must carry out his plans for expansion of his forest and the increase of his planted areas. At such times the directors will be freer to vote funds for capital expenditures. After the boom is over and the bottom has dropped out of the market it will be too late to try to build up the forest capital. Funds will not be available.

Thus the investing public is the ally of the forester and the forester the protector of the interests of the investing public.

PUBLIC OR PRIVATE PRODUCTION OF PLANTING STOCK—WHICH?[1]

By A. D. La Monte

Undoubtedly this question to most foresters is one of relatively little importance. We all agree that the most important thing is to stop forest fires and where necessary replant. As long as the stock for this purpose is available and its initial cost is within reason it is relatively unimportant where or how it is produced. After all, the great and essential problem for State and Federal foresters to grapple with is that of starting the forests and keeping them growing as fast as they are being cut.

Is the actual production of planting stock the forester's job? It is quite easy and natural for you to say "Yes, of course it is—our job is essentially one of producing timber and sowing the seed is certainly the first step." This logic I think is wrong. Are all the parts of the Ford car made in Detroit? No indeed—like most other cars, it is to a large extent assembled. The wheels, the carbureter, the battery, etc., are all made by different people and bought and paid for and put together in Detroit. The farmer does not raise his own timothy seed. So I trust you will now agree that the production of seedlings does not necesarily have to be done by the people in charge of the forest interests of the State and Nation.

Foresters, I think, are much broader than they used to be. We as foresters are apt to think that forestry is the most important problem of the country and too apt to believe that we must accomplish the aims of forestry at the expense of everything else. This is a grave mistake. We must remember that it is essentially one of a great many economic problems. The foresters in the employ of the public are not only foresters—they are also public servants. As such their every act should be governed by the question, "Is this to the best interests of the public?" Possibly many of you think all this sermonizing is a little impertinent and quite beside the main question of this talk—to the contrary, it is not. Is the production of reforesting stock by the different State for-

[1] Read before the Allegheny Section of the Society of American Foresters, at Harrisburg, Pa., February 29, 1924.

estry departments to the best interest of the voter and tax payers of the respective States? I think not.

From now on I want to present certain questions bearing on the subject and let you answer them in your own minds. Going into the pro's and con's would take far more time than is available at this meeting.

1. Should the lumber, paper, and coal industries, who will benefit the most from well stocked forests, expect the butcher, baker, and candlestick maker to help pay the cost of supplying planting stock? It is easy to say that all should pay because all are benefitted by thrifty forest conditions. This may be theoretically true but actually you would have a hard time proving that a druggist in Harrisburg is more prosperous because the Central Pensu Lumber Company has a thrifty stand of timber near Williamsport. Times might be better in general for every one as a result of good forests but certainly the class that reaps by far the greatest benefit is the forest industry class.

2. As public servants should foresters be willing to see private industry stifled? By this I mean of course the business of growing reforesting stock.

3. Would not the elimination of nursery details give public foresters more time for the essential problems of reforesting and fire protection?

4. Can the State nurseries come any nearer to supplying the demand for planting stock than private nurseries can? Even today several State forestry departments get all their stock from private nurseries. They get all they want and at a satisfactory price. I believe New York State produces about 12,000,000 seedlings a year. This would plant about 15 square miles—is that enough?

5. What about the price? As stated before under the present State nursery system every one helps to pay for the production and New York State puts out her stock at $2 a thousand, which is supposed to be the actual cost. Is this really the cost? Possibly it is. Private industry can not think of producing stock as cheap as this and never should try to claim that it can. If $2 planting stock is necessary, then private enterprise is absolutely out in the cold. We will say that an average softwood artificially planted stand will in 50 years yield 25,000 feet per acre, worth at that time $25 per thousand stumpage. This would be $625 per acre at the end of 50 years. Now there is the initial cost of the land with its running interest charges—taxes, etc., interest at 6 per cent, $2 per acre for the planting stock, would in 50 years

be $36.84, and the interest on $10, planting stock would be $184.20. Admittedly this is quite a slice into the profits but is it too much? I hardly think so. I have taken an extreme example. Several profitable things would be made before 50 years. Very likely in many cases the final crop would be harvested long before 50 years' time. Again the stumpage value in the future very likely will be considerably more than $25 per thousand.

It seems that in general the supplying of planting stock by the States produces an artificial economic condition that is not healthy. If forestry is a paying proposition, it should be able to get along without financial assistance from the general public.

I had better say frankly at this time that I am in the nursery business and want very much to supply seedlings for reforesting purposes. I think I can do it for considerably less than $10 per thousand. This paper in your eyes now is probably nothing but nurseryman's propaganda. It is propaganda. I won't deny it. Every cause makes use of propaganda, the cause of forestry included, and why not?

There is something to be said in favor of State nurseries. They are a big advertisement for forestry—yes, good propaganda. They encourage planting.

Where a State has thousands of acres of State land to reforest it will in many cases find it entirely feasible to grow its own trees; but why not give the nursery industry a chance on the rest. There are over 600 nurseries in New York, about 300 in New Jersey, and about 400 in Pennsylvania. This means the employment of thousands of men in just these three States.

It is my honest conviction that while this subject is of vtial interest to nurserymen; it is of the utmost importance to the general public. Further, I firmly believe that the private production of planting stock will not be the slightest set-back to the advancement of forestry.

FREE FOREST TREES—IS PENNSYLVANIA'S POLICY SOUND?[1]

By John W. Keller
Department of Forests and Waters, Harrisburg, Pa.

Tree planting in Pennsylvania has been given a place in forest work second only to forest protection. It plays a very important part in bringing back idle forest land to full production. Some tracts will come back naturally with a satisfactory growth of desirable trees if fires are kept out, but there are 3,000,000 acres of abandoned farm land, worn out woodlots, severely burned areas and others of both State and private land in Pennsylvania that must be planted with trees to restore satisfactory production. An aroused public favoring tree planting, such as we have in this State, is sure to demand a large supply of tree planting stock. This stock can be supplied from two principle sources, the commercial nursery and the State nursery.

It is no longer necessary to prove the ill effects of idle timber lands to the State and Nation. It is admitted by all and public welfare demands that these lands be brought back to production. This public interest in these lands is responsible in a large part for the existence of the State nursery.

Is Pennsylvania's policy right in growing forest trees for planting on private lands?

The law of 1915 authorizing the distribution of trees from the Pennsylvania State nurseries to private land owners is, no doubt, responsible for the fact that there are no commercial forest tree nurseries in the State. The trees distributed to private land owners are for reforestation. They are not suited in size or shape for shade and ornamental plantings and will not be supplied for such uses. It has been said that "planting breeds planting" and setting out trees for future timber encourages the sale and planting of shade and ornamental trees. This may or may not be true. It is sufficient to say that this policy of growing forest trees in the Pennsylvania State nurseries for private use has met no opposition from commercial nurserymen.

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[1] Read before the Allegheny Section of the Society of American Foresters, at Harrisburg, Pa., February 29, 1924.

Some commercial forest tree nurseries have been supplying a high grade of trees at, what they consider, satisfactory prices. Such nurseries have been doing a good work and must be allowed a reasonable profit for their efforts. However, to give the buying public the benefit of low prices all unnecessary factors that cause the prices to soar should be eliminated. Some of these factors can be minimized or entirely removed in State nurseries that are essential in commercial nurseries.

Losses in the nursery business are sometimes very high. These losses may be due to unfavorable weather conditions, attacks by destructive insects and diseases and other agencies over which the nurseryman has little or no control. In addition to these factors the demand for trees is spasmodic which is the result of "drives" that are usually carried on by individuals or organizations that are not interested in any way with private nursery companies. The kinds and ages of trees demanded by the public vary greatly and it is exceedingly difficult to forecast the requirements for tree planting stock from two to five years in advance when the seed is planted. The failure to predict the kinds and ages that can be sold, causes a loss that must be added to the sale price of other trees. This failure has reacted unfavorably to some commercial nurserymen, leaving them with large numbers of trees that could not be placed. Any surplus planting stock in State nurseries can usually be planted on the State forests and does not become a dead loss.

In order to prevent losses from an over supply, commercial nursery companies as a rule hesitate to plant large quantities of tree seed because the demand for kinds and ages of planting stock may change before the trees are ready for shipment. This fear has caused a shortage of given kinds of trees. This fact was brought out clearly in 1923 when the supply of white pine in the eastern United States was completely exhausted long before the planting season.

It is an easy matter to purchase any of the European or Asiatic tree seeds, but it is usually a difficult task to find large amounts of American-grown seeds on the market. The native red pine, white pine, pitch pine and white spruce are among our best conifers to plant in Pennsylvania, but the scarcity of seed together with a heavy demand sends the price skyward. Quotations of red pine at $30 per pound are common and it has reached $36. At present labor costs, red pine seed can be collected and placed for $17.50 per pound with a good profit to collector and broker. The commercial nursery must grow trees for which there

is a demand regardless of the price of seed, because a supply of trees that are scarce will help sell the other kinds. This high seed cost is passed on to the purchaser by including it in the selling price. State Forestry Departments cannot afford to become a party to seed speculation. Limited appropriations wisely spent will not permit it. When $30 is asked for red pine the State department can very well purchase white pine at $2.50 or pitch pine at $3.75 per pound. The public will plant the trees and get good results.

State nurseries are able to supply trees to planters at a cost from 50 to 500 per cent less than the same trees may be purchased from commercial nursery companies. An example is 3-year-old white pine seedlings which can be grown in Pennsylvania nurseries at $3 per thousand, but the lowest commercial nursery price is $6 per thousand, and the highest quotation noted is $15. Possibly the largest factors in this saving are the labor, supervision and tools, all of which may be used on other forest projects when nursery work is slack.

The commercial nurserymen must grow trees to meet the demand of the planters. Some of these planters have got their impressions in foreign countries and, while the trees they have seen may or may not thrive here, commercial nurserymen try to grow a limited number to meet the demand.

Then again some seedlings are very easily grown and they are put on the market without regard to their fitness to the climate. Persons who buy trees and plant them out of their range are usually doomed to disappointment. Millions of dollars were made a few years ago through the sale of catalpa seedlings which were not hardy in this State. The hybrid walnut that is advertised to grow 18 inches in diameter in 20 years, the eucalyptus that is reported as producing railroad ties in 10 years, and other kinds of trees of reputed phenomenal growth will not produce these results in Pennsylvania and the public should not be humbugged into buying them. Trees are not grown in quantity in State nurseries unless experience justifies it and they are not offered to the public unless they are suited to the climate and general conditions.

State nurseries have been conducted for a number of years and planters in these States have been able to get tree planting stock suitable to their needs at a low cost. These nurseries have grown good stocky trees of the species best adapted to planting in these States. The chance for an error in the kinds of seeds planted is reduced to a mini-

mum since they are chosen by the leading foresters in the State who mold public opinion to the need of tree planting. Where substitutes must be used the best trees are selected. The shortage of native tree seeds may be a blessing in disguise since experiments are carried out by planting foreign seeds that otherwise might not be given a trial.

It would appear from these statements that the logical source of forest tree planting stock should be the State nursery because:

First. Trees can be grown and made available for the planter at a low cost.

Second. A sufficient supply of the best trees for planting in the State will be grown.

If it can be granted that the State forest tree nursery is to be given preference over the commercial nursery in supply forest trees for private planting the question of the distribution of trees looms up as one of the most important factors. Various methods of distribution are in use.

Twelve States operate forest tree nurseries. Two States distribute trees at cost of packing and transportation, three States at the cost of production, two States at a "reasonable figure" or "medium cost," four States on "terms approved by the Commission or the Governor," and one State at a cost "not exceeding the cost of production." Only one State reports that the nursery is self-supporting from the sale of trees. In addition to these 12 States, the States foresters of two others that do not have nurseries take orders within their States and purchase trees from Federal forest and commercial nurseries which are supplied to planters at a cost below the usual retail price.

It is generally agreed that it is not good policy for either the State or Federal Government to give away anything of value because it will be applied for by persons who will not make the proper use of it, consequently the practice will result in waste.

Trees are not given away by any State without some charge to the planter, to the best of my knowledge. Where the law provides for "free trees" it also provides that the applicant shall pay a small charge for lifting, packing, or transportation at the nursery, which policy differs little from paying a limited sum for the trees.

In Pennsylvania we are striving to get land owners to plant trees on their idle land that is not more valuable for other purposes. As an inducement State nursery-grown trees are offered for reforesta-

tion in the State at the cost of packing and transportation which amounts to approximately 85 cents per thousand trees. Large transplants, that is, more than 4 years old, are not distributed for planting on private property. Most of the trees distributed to individuals are 2 and 3 year old seedlings. With this policy of distribution it is necessary to place a maximum limit of 100,000 trees to one applicant to give justice to the small planter and a minimum number of 100 trees of one species to facilitate shipment at the nursery.

The cost of packing and transportation at the nurseries varies with the size of the trees. A 2-year-old hard pine will average 7 inches from collar to tip. One thousand of these trees can be well packed in a corrugated carton, size 15 by 13 by 11 inches, which will cost 16 cents each. The moss, water proof paper, wrapping cord, sorting, counting and tying of the bundles, etc., will amount to 56 cents. The transportation from the nurseries to the post office or express office will cost an additional 10 cents. The total charges in Pennsylvania for 1,000 2-year-old hard pines delivered to the post office or express office will amount to approximately 82 cents. A 2-year-old larch will average 12 inches in height. One thousand can be well packed in a corrugated carton, size 10 by 18 by 26 inches, which will cost 28 cents each. The moss, water proof paper, wrapping cord, sorting, counting, tying and delivering to the station will cost 75 cents, making a total of $1.03. Three-year-old white pine or Norway spruce seedlings will average 8 inches in height. This is larger than a 2-1 transplant. The cost per thousand for shipping will amount to 90 cents. The actual packing and transportation costs are charged to the applicant. The lowest charge is 40 cents on 100 trees, which is the minimum number that will be supplied.

Is Pennsylvania's policy sound in distributing forest trees to private land owners at the cost of packing and transportation?

The argument has been advanced that trees should be distributed at cost since, if the proper use is not made of them, the State loses nothing. It has also been said that the planter will be more careful in planting and caring for trees when he is compelled to pay well for the planting stock. The State should not be asked to bear any unnecessary loss and it is very desirable to have trees planted in the best possible way. However, in a State where at least 16 per cent of the land area good only for timber production is not producing timber, and where 10 per cent of the land area must be planted with trees to bring

back satisfactory production, the important things is to get trees started to grow.

Many land owners can be persuaded to plant trees when they may be obtained at a cost of 85 cents per thousand, who will not plant if the cost is $3 per thousand. Particularly is this true of the farmers who represent 75 per cent of the Pennsylvania tree planters and who own more than half of the land that must be planted.

Mining companies, water companies, municipalities, and other tree planters set aside a budget for this work. A $5,000 budget will plant 700,000 trees when they are obtained at a cost of 85 cents per thousand. This same amount will plant but 500,000 trees when the planter must pay $3 per thousand or the cost of production. This is an increase of 40 per cent in the number of trees planted and the area covered. The township, county, and State will reap larger taxes, local business will be stimulated, and, when the trees are mature, they will supply a much needed commodity. Therefore the public receives a return when trees are planted for which it rightly should pay.

I am informed that several States that have authority by law to distribute trees to private land owners at the cost of production are supplying them at a much lower cost. There undoubtedly is some reason which prompts them to make this concession. Do the officials of these States believe that more trees will be planted or that a larger number of persons will undertake the work if a lower cost is charged? May we not consider this as an act which indicates that the distribution of trees at cost in these States does not bring as good results as the distribution at a lower charge?

Many trees planted now will be cut in approximately 50 years. We may be reasonably sure that when they are cut the demand for lumber will be so great that no thought will be given to the few dollars expended by the State in supplying the trees at a small cost. This cost will be but a fraction of the freight charge on imported lumber at that time. Approximately 10,000,000 trees will be available in the Pennsylvania nurseries for shipment during the spring of 1924. The budget for the present fiscal year is $17,500, or approximately $1.75 per thousand trees distributed. This budget is smaller than for the last fiscal year.

If it is true that wood plays such an important part in our everyday life, that no Nation has ever got along without it, and that the prosperity of the industries and the happiness of the people depend upon

a sufficient supply, is it not a wise policy that spends a few thousand dollars each year for the production of tree planting stock at the cost of packing and transportation for reforesting privately owned timberlands?

In Pennsylvania we believe that distribution of State-grown forest trees at the cost of packing and transportation is conducive to the greatest planting results. This policy not only may, but should, be changed as soon as the masses of land owners reach the point where they realize the need for tree planting and understand that a profit can be made from it, regardles of the cost of planting stock. At that time trees may be supplied from State nurseries at the cost of production or even at a nominal profit to the nurseries. Land owners will not be sold to the planting idea until they can see that it is practical. We believe land owners will be convinced that tree planting is practical when they plant 20,000,000 trees annually. With favorable appropriations from the legislature, which will permit the growing of sufficient trees in the State nurseries, it is believed that this number will be demanded in from 5 to 10 years. The difference between the cost of production and the cost of packing and transportation is the price the State of Pennsylvania is paying to convince private land owners that forest-tree planting is a good financial business proposition. This is an exceedingly small price to pay for the large public benefits that are derived from it.

A demand has been created from private land owners for 10,000,000 trees nine years after the law was passed authorizing distribution at the cost of packing and transportation. The demand in 1924 is twice as large as in 1923. The results obtained from the distribution of almost 24,000,000 trees has led us to believe that supplying State nursery-grown forest trees to private land owners at the cost of packing and transportation is the logical plan for Pennsylvania.

PERSONAL OBSERVATIONS AND EXPERIENCES OF AN OLD FOREST SURVEYOR[1]

By Captain S. T. Moore

You will pardon me if I use the personal "I" in this article, but Professor Illick said I would be fully excused on account of my extreme youth.

"Sam" Clemens, otherwise known as Mark Twain, author of Huckleberry Finn and other enjoyable wood-life stories, when a surveyor was running a line near him at his home in Elmira, N. Y., made the remark that a country surveyor could bring more pleasure and more unmitigated enmity at the same time than any other class of workers. He was absolutely right, I know it. I have been through the mill. Had an opponent threaten to break my transit, been threatened with a shotgun, dodged a pan of hot water thrown by an irate Irishwoman whose bull's-eye shooting capacity was generally acknowledged, hauled into court and heard the grandest funeral oration any one could wish to receive by the opposing counsel, yet am still alive and on the job. However, I fully believe Mark was right.

THE COMPASS

The compass was invented by Emperor Houan-ti about 2634 B. C. The sailors who navigated the Indian Ocean and the Eastern Seas were well acquainted with its uses in the third century after the Christian Era, when it was still unknown in Europe. It is said to have been introduced in Europe by Marco Polo on his return from his travels in the east about 1260. Flavio Gioja, a Neapolitan sailor, effected considerable improvement on it and brought it into its present shape about A. D. 1300. The discovery of the variation in the needle is ascribed to Columbus in A. D. 1492. Robert Norman of London in A. D. 1576 found the "Dip" of the needle and made use of it in mining. The variation compass as now used is of a sixteenth century origin.

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[1] Read before the Allegheny Section of the Society of American Foresters, at Harrisburg, Pa., Feb. 29, 1924.

The invention of the compass by the Chinese is probably the reason why it is generally used to decipher the Chinese puzzle of our overlapping and complex warrant surveys. The Chinese, however, had sense enough to confine its use to navigating their pung-tongs or night boats in bootlegging campaigns.

Be that as it may, no scientific society has ever invented or put in use any instrument for land surveys better than the old magnetic compass. Improvements on the general construction of the instrument, and its finer adaptability to minute divisions of horizontal and vertical measurements have been made, but for land surveys, the old Chinese needle, possibly better constructed and magnetized, is recognized today in many heavy land law decisions. I know of several old English compasses, one of which I tried to purchase in Center County within a few years, that have been in actual use for over a century, the needles of which have never been re-magnetized.

The original compasses, however, were not divided as they are now into 360 degrees. They were divided into 32 points or "Rhumbs" as then called, and were indicated by the N. S. E. W. letters as these points actually lie on the ground, instead of having the "E" on the west side of the box as now used, the present reverse "E" and "W" found necessary ages ago when they came to plot their observations.

The divisions referred to above were lettered as follows: N, for due north; NbE, for N. 11¼ E.; NNE, for N. 22½ E.; NEbN, for N. 33½ E.; NE, for N. 45 E.; NEbE, for N. 56¼ E.; ENE, for N. 67½ E.; EbE, for N. 78¾ E.; E, for due east.

The technical meaning of a compass is a moving or passing round a circle, a circuit, or circular course. Shakespeare says: "My life has run its compass." Dryden says: "And in that compass all the world contains." These words are all very well in poetry and fiction, but Dryden would have been dust long before he was if he had been a country land surveyor.

A compass is composed mostly of brass, glass, and steel needle, but contains more unqualified stubbornness and deviltry than any other piece of machinery. I never saw a man yet whose lines did not suit him that he did not say: "That dombed compass lies." When you attempt to tell the average land owner who engages in land line disputes that the needle of a compass does not point due north every minute of the year, he immediately thinks you are handing him some gold bricks.

If a compass needle was like the works of a good reliable watch that could be regulated monthly or annually to run a true north line, it would save lawsuits, but it is a peculiarly obstinate piece of steel, yet we must blame old dame nature for its shortcomings. If the North Star would behave itself and become permanently fixed it would send many lawyers to hard work. When the North Star (Alpha Ursoe Minoris technically) that we love to look upon, pin our bread baskets to, and swear by, goes wild to the extent of several degrees; it makes even a good-tempered surveyor quake in his high top boots. You will note another peculiarity of old Polaris. Whenever you want to find it you must first find the "Dipper." It is plainly evident where the "bootleggers" get their directions from.

The variation of the needle is one of the hardest problems the surveyor has to solve. Colleges and cheaper special schools have taught the pupils all they could about surveying, but when the pupil goes out to run a line he is lost. Field surveyors years ago had timber marks by which to test a surveyed line, but now the timber is gone and a surveyor is put to his wits end to know how to figure out the necessary variation by which to locate his lines, as some of the older surveyors returned their drafts magnetic north while others returned them true north. If it were not for the notes and drafts left by the old country surveyor and his actual careful work on the ground, present surveyors could not hold a case in our courts today. The courts are extremely careful about admitting in evidence any notes or drafts of surveyors who have passed on to that special corner in the future world allotted to land surveyors. Let us hope they will receive more consideration there than they ever did in this world. Many of the best old lawyers went with survey crews, submitting to all the trials of poor shelter and food, just to be better able to try a land line case.

My personal experience in surveying extends practically over my entire life. My father and four brothers were land surveyors. When old "Billy" Gwinn surveyed in Blair County in the forties and sixties my father worked with him. Much of the older part of Altoona was laid out by them. When I was a boy of ten I helped carry the chain for them. Farms surveyed then as way out of the city are now within the city limits. Unfortunately for my education, father died when I was fifteen and it was root-hog-or-die for me then. To show how one can be forced to learn certain works—in 1877 I was timekeeper on the construction work of the Delaware, Lackawanna and Western Railroad.

"Jimmy" Archbald was chief engineer. One morning as I was leaving the shanty he hailed me and told me to take the level crew, that his level man was sick. I never had run a level in my life, but we went on. Some time after that the transitman took sick and "Jimmy" sent for me. Take that transit crew. No saying of mine that I did not know how, just "take the crew." We went on. From 1886 I have devoted more time to titles and land surveys where overlapping warrants were prominent, and when the great "Father of Pennsylvania Forestry" was in the midst of his forest studies, it was natural that we should become friends in the cause. Nights spent in the woods were no terror to us then. In my mountain work we often had to spend the night on the ground as we were too far from civilization. Many nights were spent in logging camps or colliers' shanties. No one was troubled with high blood pressure then, our hungry little night companions kept the blood pressure down even below normal by their continual application to their work. Yet they tell us a collier's shanty is good for consumption. The way those midnight raiders consumed our blood was certainly a sure cure for their consumption. The night riders of Kentucky had nothing on those night raiders in a full-fledged charcoal burner's shanty.

S. V. Wingert, a splendid type of man and surveyor, was placed in charge of the South Mountain lines, and worked out the Mont Alto and Caledonia surveys in 1902-3, and in 1903 I took charge of the Licking Creek and Black Log valley surveys in Mifflin and Juniata. In 1904 I was assigned to the Perry County survey. Here we encountered one of the most disheartening storms I ever knew. Six weeks with rain daily. No chance to dry our clothes or bedding. Tents and ground soaked. Grub soggy and the roads so bad we could get in very few supplies. What a welcome "old Sol" had when he did finally smile on us.

The first years in the great forestry movement were certainly discouraging. Lumbermen would smile a sickly smile at you when you told them a timber famine would be on the old Keystone State in fifty years. They imagined the forestry movement was only a big graft and all connected with it were crazy grafters. Through it all, our dear old Doctor Rothrock worked under circumstances enough to discourage many a brave man. It was almost a hopeless task to get laws passed for either finances or help. It became a fight not with careless, wasteful lumbermen, but with legislators to secure proper laws. The valuable help rendered by Miss Dock at this critical time was never forgotten

by Doctor Rothrock. With her aid and that of our grand old engineer, S. B. Elliott, and Mr. Fulton and Mr. Conklin, laws were finally secured and finances granted to really begin to get something accomplished for the cause.

Thousands of cut-over acres burned yearly without any effort to stay the destruction, until finally the efforts of the Department began to bear fruit. Gradually the people were made to see the critical condition of Pennsylvania forests. Slowly the lumbermen themselves were confronted face to face with the fact that timberlands were exhausted without any effort to reproduce. Railroads, the chief source of the cause, were gradually brought in line for fire prevention. Great coal companies became enthusiastic tree planters and fire fighters. Under the direction of that unquenchable little fire eater, the Chief Forest Fire Warden, systematic fire patrols have been established and are bearing fine results. The people are being enlightened as to the evil results of their carelessness.

Oh, what a glorious change for the better today. Forest employees are now welcome in any district. Instead of being "grafters" they are boxes of information received with the glad hand. The forestry work today is looked upon as one of the most necessary National and State public work. I remember sixteen years ago, in purchasing a small piece of land that we wanted badly, the owner would not accept a State treasurer's check, and would not sign the deed until he had the "cash" in hand. Fortunately, I knew the banker and he gave me for my own check the amount of the deed in silver dollars in bags, and with these I went out into the mountain, got the man and wife, took them to the justice, had them sign and acknowledge the deed, gave him his "cash," and drove home late that night. Now they are glad to get the treasurer's check or any other kind of cashable paper, and are even presenting us with lands for forestry purposes.

Records show no millionaire surveyors, but they do show that even surveyors can become noted. George Washington, our first and greatest President, was a land surveyor. Abraham Lincoln, the Emancipator, who had only attended school for six months, fitted himself for a deputy surveyor, and according to tradition he was too poor to buy a chain, and selected a long grape vine and carefully divided it into links with a foot rule. For this reason Abraham did not belong to our chain gang. A surveyor's line ran in 1767-8 established a location for one of the greatest disputes in American history. The North said to

the South: "If you cross the Mason and Dixon line we will lick you." The South crossed the line and were severely paddled and decidedly licked. That line has always been known as the "Black Line," and even to this day there are people who doubt whether "Honest Abe" did a favor to American citizenship when the beneficiaries of that expensive war flood the North with illiterate members of the race and become a burden in the criminal courts of the land.

Washington and Lincoln were rare examples of the surveying fraternity. No other surveyor ever rose to such high fame. They generally die unheralded and are buried without flowers. No great outburst attends the funeral of a surveyor who perhaps has done more actual legal good in his community than the minister who reads the Psalms over his remains. His work was done by metes and bounds conscientiously performed and paid for by remarkably small compensation. Not until later years, when the price of land rose to such phenominal heights, did the profession of land surveyor become prominent. The survey of disputed lines required the services of the ablest members of the profession. Even after years of study and training, the payment of $10 per diem was thought an enormous fee, while a common mud slinger received as much or more.

Land surveying is supposed to be taught in nearly all of the colleges and side-issue universities, but to let one of their graduates attempt to locate some of the Pennsylvania mountainous land lines is a dangerous proposition, and the land owner will probably have to pay dearly for his whistle. A graduate civil engineer may be an expert in his line, but a failure when it comes to locating unseated land lines. The surveyor's marks of 1793 on trees are as plain as day to an old land surveyor and as clear as mud to a graduate civil engineer. A woodsman born and raised in a lumber job on the mountains can not tell the difference between a bruise inflicted by a falling neighbor tree and an axe mark by a surveyor. An axe mark made by a trained survey crew is so absolutely indisputable that the highest courts have paid unstinted praise and legal rulings to surveyors whose dust lie in forgotten graves, but those notes and drafts left behind him are his greatest monument. One of the most interesting relics of a surveyor's axe mark was an exhibit of a block taken from an old white oak tree then living, and used as a "living witness" in a large land line suit where the land had become valuable on account of the coal under it, that had not been dreamed of when the original survey was made. The suit was in progress in the court house of a central Pennsylvania county. The

white oak block was placed in evidence and one of the old land surveyors testified. He showed the axe mark of 1793 and a fire mark of twenty years later, and a subsequent surveyor's axe mark of 1812. He then pointed out the growths of healthy years and unhealthy years by the size and color of the annual rings of that old white oak tree. The old surveyors reading of the silent block was a wonderful lesson in woodcraft. Nature does not lie. Figures do not lie, but any expert can manipulate figures. No one can manipulate the growths of a tree as shown by its annual rings.

Prior to 1776, so far as we are able to find in the records, only English surveyors were allowed to survey the public lands. The first surveys made in this province were the manor lands for the proprietaries. When the lands of the province were formally opened to settlers any one who could read a compass, or even saw one used, school teachers during vacations, and quandam lawyers with small clientele, were sent out to survey the lands for the settlers. Fortunately, all the compasses then used were of good English make with well magnified needles, and while only reading to half degrees, the results as found by later improved methods, were wonderfully accurate.

During the great land sales of 1790 to 1795 the big land companies exploited emigration and settlement, most of which resulted in failures, surveyors of all grades were sent out to establish the lines of lands so taken up, especially after what is now known as the Late or Last Purchase. Each deputy surveyor was given a district, the east and west lines of which were run and marked from the Susquehanna River due north to the State Line. The interior lines of his district were then supposed to be run and marked or divided into blocks or tracts of 500 to 1,000 acre tracts, but if he became suspicious of the Indians, or his energy flagged, he would run very few of the interior lines on the ground. A few of these old surveyors were gifted with humorous ideas. Charles Lukens, brother of John Lukens, Surveyor General in 1774, was making surveys on Bald Eagle Creek with his headquarters on "Great Island" (Lock Haven) says in his unique notes of 1769: "Left Great Island and run line up the creek for about three miles. Scouts ahead reported large body of Indians. Returned to camp. Rained next day, did not go out, but stayed in camp and drank grog with Aaron Levy." It is said of Frederick Evans, whose district included a large part of what is now Center county, that he made his surveys on horseback. From an established corner he would sight his

compass to some distant mark, a peculiar shaped tree, large rock or stub, tell his men to go straight for it and mark the line, mount his horse and go to it and wait for his men. Their "straight" line can well be imagined, yet the highest courts in the land hold that the crooked "straight" line they made is legally correct. This fully established and legalized decision has made many lawyers rich and powerful.

The price set by law to be paid for vacant land has undergone great changes. "Girard," a famous writer in the Public Ledger, speaking of early land titles says: "Pennsylvania proprietaries once paid a few thousand dollars to the Iroquois Indians for the land now comprising many of the northern counties of the State." Cheap? Yes, but when the State offered it at 80 cents an acre only a few acres were sold in seven years. Benjamin Franklin advised a reduction to 53 cents, yet no townsmen became settlers. Then in the year of the terrible yellow fever epidemic in Philadelphia the lands were offered at 13 cents per acre and in three years 13 million acres were sold, but mostly to rich men. Robert Morris bought 163,000 acres. Thomas Willing, president of America's first bank, bought 311,000 acres; George Meade, 306,000 acres; William Bingham, then the wealthiest man in the State, took 125,000 acres; Samuel Wallis, the largest landowner in the Loyalsock region, took 100,000 acres. Schools took up many acres for future uses and speculation. Dickinson College, 7,000 acres; Episcopal Academy of Philadelphia, 10,000 acres; Reading Academy took 5,000 acres along Pine Creek, and Washington Academy took 5,000 acres, and so on. Much of this land is now in the Forest Reserves, but the Bingham lands have the most interesting history in Potter, Tioga, and Lycoming counties. Pages could be written on the settlement efforts of Bingham, Morris, Willing, and others. The tragic fate of Ole Bull shows the result of the futile efforts. Those who were lucky enough to hold their land until the oil and coal underneath them were discovered were fortunate; the others, many of them, died land poor.

The lines of these purchases were generally surveyed in large blocks, but even then it had to be done from tents, bark shacks, log cabins, or spruce boughs and blue sky covers. Even in our surveys of 1914 of State lands, we were at very tiresome journeys from our work, long marches through brush and over mountains to begin our day's work, and as long or longer getting back at night. Yet we see sometimes things that amuse us. Visiting a lawyer's office years ago in Huntingdon, I saw over a large built-in vault on the wall an old-style compass

and Jacob's staff. The old attorney seeing me look so intently at the instruments, asked my interest in it. I told him it was the finest and most comprehensive combination I had ever seen, because I knew the old surveyor's compass and staff had made more dollars to put in the lawyer's vaults than any other class of artisans.

With all the trials, tribulations, complexities, and adversities of the surveyors, we are proud of the fact, and glad to proclaim it to the world, that the surveyors attached to this department during the last twenty years were successful in running out, locating, and marking over one and one-quarter million acres of land with only four lawsuits, all of which were decided in our favor, one can not help but think their work was a labor of love more than emolument. This is a record we can well be proud of, and when the new bond issue is passed, as we firmly believe it will, if we add several more million acres with as good a survey record as the past, the writer will have his fondest hopes gratified, regardless of compensation.

WHERE OUR WOOD GOES TO[1]

By Joseph S. Illick

Some time ago I considered the vital economic subject: "Where Our Wood Comes From." The results of this study showed that Pennsylvania now imports 80 per cent of the lumber consumed within her borders and that only 20 per cent comes from her native forests. A recent survey of the pulpwood industry of this State revealed the startling fact that more than 70 per cent of the pulpwood used in the 13 mills of the State is imported.

A general survey of the forest situation of Pennsylvania was undertaken a few years ago, and among the conclusions was the fact that there is now, and that there will be, sufficient forest land in the State to supply all the ordinary needs of her industries and her people if all the forest land is protected properly and cared for in such a way that the trees will be given a chance to grow.

It is a satisfying fact to know that we have enough land to meet all our wood needs, but in working out a sane program of handling these lands it is important that consideration be given not only to the summary needs of the State, but also to the special needs of specific industries located in different parts of this industrial Commonwealth.

The H. C. Frick Company, with its main office in Pittsburgh, uses approximately 71,000,000 board feet of lumber annually. This is a greater quantity of wood than was consumed in the whole Pittsburgh district in 1860. To insure a permanent supply for this one company in an amount equivalent to that it is now using will require about 150,000 acres of well-managed forest land. The Baldwin Locomotive Works uses approximately 12,000,000 board feet annually. The Lehigh and Wilkes-Barre Coal Company uses each year about 6,000,000 board feet of lumber, 1,660 cars of props, 227 cars of ties, and a considerable quantity of other miscellaneous wood products. Four of the large anthracite companies use almost one billion board feet of lumber annually, an amount almost twice as great as is cut each year in Pennsylvania.

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[1] Read before the Allegheny Section of the Society of American Forestern at Harrisburg, Pa., Feb. 29, 1924.

The total wood needs of the wood-using industries of Pennsylvania are enormous, and with the industrial development of the State the amount required in the future will continue to increase. The wood needs of this State are not only enormous but they are very diversified. There are so many different kinds of industries in the State, each one requiring specific kinds and grades of wood. This industrial demand for a wide range of woods suggested the need for a detailed study of the principal wood-using industries of the State, rather than a general statistical study of the total or aggregate needs of the industries of the State.

Among the many wood-using industries of the State are some that are temporary in nature, and others that are permanent fixtures. In fashioning a program of wood production it seems to me to be very important to give fuller consideration to the wood needs of the permanent industries than has been done in the past. This fact suggested to me the subject, "Where Our Wood Goes To," for I think it is very important in working out an economic plan of forest development and wood production that consideration be given to the present and particularly to the probable wood needs of the permanent wood-using industries of the State. By permanent I mean those large wood-using industries that are not portable, but are permanently placed on account of their peculiar nature, ponderous layout, and high capital investment.

To illustrate my point of view I will present some interesting and significant facts that have been brought together through a careful and detailed study of two important wood-using industries of the State, namely, (1) the pulpwood industry, and (2) the hardwood distillation industry. The wood consumption of these two industries is rapidly approaching a million cords a year, and to maintain these industries permanently at their present rate of consumption will require approximately 1,000,000 acres of adequately protected and carefully managed forest land.

Figures have just been compiled showing that the 13 pulp mills operating in Pennsylvania consumed 446,662 cords of wood during 1923. On this amount 344,498 cords came from outside of the State and only 102,163 from within the State, which shows that 70.3 per cent of the pulpwood used by the pulp mills of Pennsylvania was imported. To know how much wood the pulp mills of the State need anually is quite important, but it does not begin to answer the question of pulpwood needs. In order to develop a sane program of wood pro-

duction it is necessary to know where the mills are located and the particular process of pulp manufacture used, for the latter determines in a large measure the kind of wood that is used. The three processes of pulp manufacture used in this State are the mechanical, the sulphite, and the soda. During 1923, 256,097 cords were treated by the soda process, 189,203 cords by the sulphite process, and only 1,363 cords by the mechanical process. This shows that 57.3 per cent of the wood was treated by the soda process, 42.3 per cent by the sulphite, and only one-fourth of 1 per cent by the mechanical process. Two of the thirteen mills manufactured pulp by the mechanical and sulphite processes, three by the sulphite, while eight mills used the soda process exclusively. These basic facts are necessary in order to ascertain the particular kind of wood that each mill uses. As a rule spruce, fir, and hemlock are the principal woods used by the mechanical and sulphite processes. It follows, therefore, that in developing forests to maintain the mills equipped with these processes of manufacture, that the particular kind of wood they can use should be grown close to them. It would be economically unwise to grow stands of birch, beech, and maple at a short distance from a sulphite mill, which can not use this type of wood, and in another part of the State near a mill equipped with the soda process, to develop stands of spruce, fir, and hemlock, which are adapted to the sulphite process. Forest growth factors must naturally be taken into consideration, but other things being equal it is economically wise to grow the particular kind of wood that is needed by an industry as close to the consuming point as is possible and practicable. It is important to know where our wood goes and where it will go in the future in planning the establishment and development of forest stands. The planting of 8,000,000 well-placed trees may be a more profitable and a more creditable accomplishment than the planting of 10,000,000 trees set out with no regard to the industries that will need them. In order to project a good forest production program one should know not only the facts of the industry as it now exists, but also its history, and especially its future tendencies.

The growth of pulpwood consumption in Pennsylvania has increased at a prodigious rate. In 1870 there was only one establishment in the State with a capital investment of about $3,000. Three persons were then employed and the total annual wage approximated $700. The raw material was valued at $2,350 and the output of the industry was $5,000. This small establishment was driven by one 16-horsepower

water wheel. During the decade following 1870 there was considerable development, for in 1880 there were two pulp mills in the State with a capital of $510,000. More than 200 persons were then employed and the annual salaries amounted to $97,000, and the annual output was estimated at $463,195. Now, only 50 years after the pulp industry started on so small a scale in Pennsylvania, it has a capital investment of $50,000,000, employs more than 7,000 people, pays out annually over $12,000,000 in wages and salaries, and turns out products worth about $20,000,000 each year.

The increase in the pulpwood consumption in Pennsylvania is shown by years and number of cords as follows: 1870, 250 (estimated); 1880, 20,000 (estimated); 1899, 177,419; 1909, 295,038; 1919, 423,822; 1920, 489,211; 1921, 320,067; 1923, 446,662.

PULPWOOD CONSUMED IN PENNSYLVANIA, 1923

Kind of wood	*Number of cords*	*Per cent*
1. Spruce	121,532.61	27.3
2. Poplar (popple and aspen)	89,048.00	19.9
3. Jack, pitch, and yellow pines	82,802.25	18.5
4. Beech, birch, and maple	56,229.00	12.6
5. Gum	21,292.00	4.7
6. Hemlock	15,182.10	3.4
7. Balsam fir	9,000.00	2.0
8. Yellow poplar (tulip)	[a] 8,096.00	1.8
9. Slabs and other mill waste	43,480.43	9.8
Total	446,662.39	100.0

[a] Gum and poplar.

COST OF PULPWOOD USED BY PENNSYLVANIA MILLS, 1923

Kind	*Total cost*	*Average cost per cord*
1. Spruce	$2,540,274.61	$20.89
2. Poplar (popple and aspen)	1,789,248.70	18.71
3. Jack, pitch, and yellow pine	1,321,758.54	15.96
4. Beech, birch, and maple	903,366.22	16.06
5. Slabs and other mill waste	525,528.01	12.08
6. Gum	368,315.76	16.14
7. Hemlock	184,682.18	12.16
8. Balsam fir	201,420.00	22.38
Total	$7,834,594.00	$17.54

It is not only important to know the kind of woods and the amount of each used at the present time, but also the tendency shown in the use of different woods. The rapid decrease in the use of hemlock used by the pulp mills of Pennsylvania is shown by years and quantity (cords) as follows: 1905, 90,692; 1906, 109,020; 1907, 121,316; 1917, 10,985; 1920, 3,942; 1921, 5,845; 1922, 4,930; 1923, 15,182.

Just as there has developed a decrease in the use of hemlock, so there has been a considerable increase in the use of pine, as is shown by years and quantity (cords) as follows: 1905, 24,367; 1906, 42,084; 1916, 61,145; 1920, 105,757; 1923, 82,809.

The increase in the consumption of pine in the pulp mills of Pennsylvania has gone forward at a rate similar to the general increase for the whole United States, for in 1905 only 57,399 cords were used, while in 1916, 170,378 cords were consumed, and in 1920 the consumption of pine had increased to somewhat more than 363,000 cords.

The survey of the pulpwood industry of the State shows not only the quantity and kind of wood used by each mill, but also the price paid for the different kind of wood and indicates the tendencies in wood consumption and prices. Requests for this information are received frequently and it serves as a reliable means of bringing the wood producer and the wood consumer together. Having this information available does not only make possible the giving of information to the persons in the business of selling and buying wood, but is of great value in outlining a sane and practical program of wood production for each forest district in the State. It seems to me to be a folly and an economic crime to plant a particular area with trees primarily suited to the production of sulphite pulp at a considerable distance from a sulphite pulp mill, if a similar area near a sulphite mill is available; and it seems equally ridiculous to develop forest stands adapted to the production of soda pulp in places where wood used in the manufacture of sulphite pulp has a better market.

In addition to the pulpwood industry, a study of the hardwood distillation industry has been completed, a study of the tanning industry and of the wood used by the soft and anthracite coal mines is in progress.

The hardwood distillation industry has a very interesting history in Pennsylvania. The first plant was erected at Brandt in Susquehanna County in 1869, and as late as 1886 there were only three plants in operation in the State, while now there are thirty-five plants with a

total annual capacity of approximately 400,000 cords, which means a total daily capacity of 1,373 cords. The plants now in operation range in size from a small plant with a daily capacity of 10 cords to the largest plant with a capacity of 140 cords a day. The plants are located in seven counties in the northern part of the State where the beech, birch, and maple type prevails. They have a total capital of almost $7,000,000, and the value of their products in 1920 almost reached $8,000,000. The industry employs about 2,000 wage earners and pays out annually about $2,000,000 in wages and salaries.

In order to maintain these acid, or chemical plants as they are usually called, upon the present basis of consumption, will require close to 500,000 acres of well managed forest land. This means that about 4 per cent of the total forest area of the State will be required to supply the needs of this one industry, which now owns within this State 135,948 acres of forest land.

The principal kinds of wood used by this industry are hard maples, beech, birch, hickory, ash, oak, and ironwood. A very small percentage of cherry and elm are used, for their chemical yields are low, and basswood is too soft and light, and chestnut is too rich in tannin. It is in the northern part of the State where these plants are now established that attention should be given to growing the kind of wood that they use and will need.

I have used the pulpwood and acidwood industries to illustrate the importance of knowing "Where Our Wood Goes To" in working out a sound program of wood production. To maintain these two industries alone at their present rate of consumption will require close to 1,000,000 acres of well-managed forest land. I see no good reason why the forest land in the State of Pennsylvania should not supply all the wood these industries need, but in order that the production of the raw material may go forward on a sound basis, I feel that the location of the mill and the particular kind of wood that each mill will need should be considered in a sound forest working plan. I think that "Where Our Wood Goes To" is a vital economic question and one that deserves more consideration than is now given to it.

We must do more than produce wood. It must be produced economically and be marketed at a profit. Some years ago while reading the introduction of a book on farm management I was impressed with the statement that in raising a farm crop there are two important factors to consider, namely, (1) the economic production of the crop,

and (2) the profitable disposal of it. The author emphasized the fact that no matter how economically a crop may be produced, the business is not a success unless that crop is disposed of at a profit. I will not go so far as to state that foresters need to be lumbermen or even wood merchants, but I am satisfied that there should be open channels of information between them, and markets should be considered in making plans for any crop, and particularly for a forest crop. It seems to me that in building up our forests we should be careful that they are built up in such a way that their products will find a ready sale in the home markets instead of remote markets. The forests should be so built up with reference to the industries dependent upon them that the long haul will be eliminated. To be able to boast of attractive stands of trees and high yields on our forest land is not all that is required of us. We naturally want high yields, but they should be of a kind and quality that will be needed by the local industries. I am inclined to think that thus far we have focused our attention entirely to the question of securing big yields, getting exceptional growth, and planting a large number of trees without taking into consideration as fully as we should the wood needs of our wood-using industries. If we keep ourselves informed of "Where Our Wood Goes To" we will be able to build up a forest business that will not only be silviculturally recommendable but economically sound.

TO WHAT EXTENT SHOULD GRAZING BE A FACTOR IN FOREST MANAGEMENT PLANS?

By John H. Hatton
United States Forest Service.

With grazing now occupying such a prominent place in the management of the forests in this country, I should say no forest management plan would be complete without some definite reference to it, even though it might be a negative reference. The very prominence of the grazing activity and the need thus created to study its relation to forestry and future forest production has perhaps emphasized the subject more in this country than in most countries, unless it would be British India, whose grazing uses and problems apparently resemble very much our own. There is this difference: elephants and buffaloes are listed in the class of animals grazed in that country. I might say in passing and by way of comparison, however, that only 16.4 per cent of the British India Forests are closed to all grazing, leaving 5/6 of their forested area open to live stock in greater or less numbers. Some 13,000,000 animals of different kinds are accommodated. Here we accomodate some 11,000,000. Where grazing is injurious or questionable, working plans are prepared with a view to meeting pastoral and forest requirements. I quote from a publication of the Forest Botany Series of the India Forest Memoirs as expressing the attitude I believe United States foresters should take, and I may say have taken more and more in recent years:

"In many parts of India, with the increase in the numbers and in the prosperity of the local population of recent years, the number of cattle for which grazing is required in the Government Forests has steadily risen and the question of what measures are to be taken in order to satisfy as far as possible the urgent needs of the people with regard to fodder and grazing, without thereby unduly decreasing the area required for the satisfaction of the wants of the country in respect of wood, fuel and other forest products, for the protection of the headwaters of streams and for improving the water supply required for cultivated tracts, is now one of great difficulty and of pressing importance.

"In whatever way a solution of this question of securing a satisfactory allotment of forest areas for these antagonistic interests is ultimately arrived at, it appears certain that large areas of the greatest value as grazing grounds, or as areas productive of good fodder grass, to meet present needs, or to serve as a reserve in times of famine, will always be situated within the boundaries of the Government Forests and such areas will consequently remain under the management of the Forest Department. It is also clear that with regard to such areas, the forest estate will not adequately fulfill its task of satisfying, to the full extent of its possibilities, the needs of the people in respect of the produce which it is capable of yielding, until grasslands are managed in such a way as to make them most productive of the best class of article required from them, i. e., until they are made to yield the maximum quantity of the best fodder grass which they are capable of producing.

"On the other hand, large areas of grass land exist in forests almost throughout India which are not needed primarily for the production of fodder and which have been for many years carefully protected from fires and grazing in the hope that they would soon become naturally reforested, with, in many cases, so far as can be seen, little or not practical result. Many of our forest grasslands also are annually burnt under proper control in order to diminish the danger of fire damage to the surrounding forest which would result from the accidental firing of the masses of dry inflammable grass contained in these areas in the dry season. Little is known at present regarding the effect, injurious or otherwise, of these annually repeated fires on the production of fodder, or on the capacity of the soil to produce good forest growth."

If Mr. Hole of the Imperial Forest Service, who wrote the foregoing sentences, had been in the United States instead of British India and had used the same language, he could not have stated our own problem much better, although I think he has stressed "antagonistic interests" a little too hard for our conditions.

But most of the older countries, practicing, as they do and have, very intensive forestry under sets of conditions, both economic and natural, materially different from our own, have given grazing little place in their forest management plans, unless to very closely restrict it or exclude it; so, except negatively, it has not entered into the management plans of those countries, as I understand it. The grazing policy and experience of these countries had a lot to do with deciding the early forest policy of this country, particularly when the forests

were managed by the Department of the Interior. This department accepted the theories and practices of older countries almost without qualification or comparative study and adopted a policy either of total exclusion or one bordering on the total exclusion of livestock.

When the Department of Agriculture in 1905 took over the management of the public forests there was more of a disposition to consider the economic importance of the industry, to recognize that American conditions were different, and to foresee the possibilities of continuing grazing. So we began to study our forest areas and natural conditions with that and forest production and forest protection in mind. However, it was a good many years before the average forester in this country who had gotten his forestry lessons from the European school of thought was willing to admit that grazing had any permanent place in the forestry of this country. There are some who still lean pretty strongly toward that opinion. As late as 1910 I was introduced at a Supervisors' meeting by one of the recognized leaders in forestry in this country, and he said something like this: "Mr. Hatton will now introduce the subject of grazing. While it is one of our important activities at the present time we must look upon grazing as transitory and to be dispensed with just as fast as the economic conditions will permit; but it must in time be dispensed with as incompatible with proper forest practice."

I took the position that we not only need not dispense with grazing but we had opportunities of using it in our silvicultural practice, in our fire protection plans, as well as to make it contribute even more than it was then contributing to an important industry and economic situation. I have been preaching that doctrine ever since, as well as before that particular occasion. I think we should recognize livestock uses as a part of the forest doctrine of this country. I believe the leading foresters of the country so recognize it; I'm sure Colonel Greeley does, so why shouldn't grazing occupy some place in our forest management plans?

The question may be asked—why in the management plan itself, why not cover it in grazing plans or general forest plans? This, of course, is open to argument, and it may be some of us would prefer to confine forest management plans purely to the timber subject, and grazing plans to grazing subjects. It seems to me however, that any plan of management, whether it be timber, grazing, or any other having to do with the protection and conservation of a forest resource should at

least make some mention of related uses, even though just enough to show the subject has been given thought and proper correlation noted and suggested. Where the question is of prominence, like sheep grazing in the yellow pine type, no doubt appropriate consideration will be given, but the question arises, how much, if any, should be given to grazing in the average management plan, or when the subject is of perhaps limited importance?

The prominence the grazing subject should have in any particular management plan would depend, I should say, upon the particular conditions of the forest to which the plan is applied. In other words, whether grazing is a positive or negative factor. The type of forest, the topography, the absence or presence of certain types of timber, tree planting projects, erosion possibilities, etc., would be points to consider, as having particular bearing on grazing uses. But each management plan, it seems to me, should have these essential subjects, which have such an intimate bearing on silvicultural practice and watershed protection, generally, definitely incorporated in the plan even though they might be disposed of in some instances by a "Yes" or "No" answer. The very fact of their inclusion will keep them before the officers preparing and approving the plan and will guarantee their appropriate consideration, or at least their refernce to other officers interested in or in charge of the grazing activity. I have felt for ten years now that the possible relation of grazing to fire prevention should be incorporated in all forest plans having to do with forest protection, such as for instance intensive grazing at strategic places of fire vantage, or the timely use of ranges when the feed is palatable; not merely following the lines of least resistance but consciously considering it, and taking certain definite steps to use it. Take, for instance, the foothill ranges of southern California, which produce luxuriant crops of vegetation like wild oats. They should be grazed before they become mature and dry and unpalatable because of the great fire menace they create when allowed to become heavy and dry.

In looking over the general forest management plan outline, I note attention is given to the relation of the working circle to the surrounding territory; the physiographic features, such as topography, climate and soil; the forest description, major silvicultural features, growth yields, situation as regards fire, the economic situation in relation to the timber itself, transportation, local industries, labor supply, markets, etc. This is all included under the topic "Foundation." Under the

management plan, among other things, the purpose as to watershed protection and to grazing, recreation and other subsidiary uses is outlined. But in looking over two plans for the Black Hills region I find no mention of the relation of grazing interests to suggested forest management. They confine themselves wholly to present timber descriptions and management and to future crops. Forest reproduction is mentioned as being satisfactory or too abundant. Now it may be that those particular working circles have no forest grazing problems, but I think even if they have not just enough mention should be made of the subjects in the plan to show the subject has been given consideration.

In our grazing studies and in our grazing inspection outlines the effect of grazing on other resources, particularly the forest, are always made prominent. The grazing reconnaissance outline, all through the various parts, brings out these points especially and provides for appropriate comments in all unit descriptions. In the questions recently raised by inspecting officers as to the apparent lack of attention to the subject of grazing versus reproduction, in practically every instance the records disclosed some comment in previous grazing inspections, and in most instances suggestions for future grazing management where a change in management was indicated. Apparently there is need for closer correlation as between officers interested because of their assignments in special phases of forest management. One way to bring that about is to provide for appropriate observations and at least community discussion in various plans having to do with the important phases of forest management. In some management plans perhaps a mere negative reference to grazing is all that will be necessary, but the very fact of its inclusion in the written plan will insure closer attention to the subject, and perhaps reduce the tendency to make snap shot comments where the subject *is* prominent.

I might conclude by suggesting a few grazing items for attention in the management plan outline. They would be about as follows and under the heading "Livestock Uses." I quote this first from our grazing reconnaissance outline, under field notes:

"Reproduction—character of, and extent of injury, or benefit from grazing. Give class or classes of stock responsible and species and height of trees injured. This question of injury to reproduction is *very important*, and data relating to it must be noted for each timber type in the description."

Then under the preparation of the management plan we have "General correlation of grazing and other uses of the forest," with special reference to the timber resource.

The question of reproduction should bring out the relation of grazing, if the area is grazed, to present conditions and to possible need for changes in management after cutting, or should recommend appropriate follow up observations. Some mention of grazing in its present or possible relation to fire protection should also be provided for, and perhaps the use of intensive grazing after seed years to facilitate germination, although observations in Idaho yellow pine did not attach much importance to this last point. My point is that we should not look upon livestock uses alone from the standpoint of actual or possible injury, but look upon them as tools in the forester's hands in many cases to effect forest protection and perhaps forest extension. In other words, in the balance of beneficial and injurious results, if the subject is at all conspicuously presented, endeavor to find out whether grazing has placed us or is likely to place us on the red side of the ledger, in our forest or silvicultural practice, or can be used as an effective tool in protecting and extending the forests; that there is a balance somewhere along the line as between injurious and beneficial effects of grazing that should be ascertained and recognized.

In the field of any accomplishment, it is a generally recognized principle, I think, that *to spend* is necessary in order *to save*. There must be certain initial investments if the largest net revenues are to be realized. The utilization of the grazing resource may involve certain expenditures of forest resources and perhaps local injury at strategic places, but we should work out the beneficial balances. The management plan, it seems to me, should provide certain space for these observations to the extent that the local situation or working circle indicates.

REVIEWS

Lumber and Its Uses. By R. S. Kellogg. Third edition, revised by Franklin H. Smith. U. P. C. Book Company, New York, 1924. 366 pages, fig. 98, tables 111.

This edition of Kellogg's "Lumber and Its Uses" is brought up-to-date by Franklin H. Smith. In the main there is very little change from the subject matter of the older editions. The tables of strength values are brought up-to-date; the notes on grading of lumber have had embodied in them some of the many recent changes in grading practice; a number of paragraphs concerning Douglas fir have been added; and the new structural timber rules promulgated by the Forest Products Laboratory have been given detailed attention. New specifications for wood block paving are given. The edition is printed on better paper and is in a better binding than the earlier editions.

Chapter by chapter the subject matter includes a discussion of the structure of wood, written in an easily understood style. A discussion of the properties of wood—mechanical, physical, effect of moisture, etc.—in another chapter, is accompanied by a number of tables in which the woods are arranged according to their strength values rather than alphabetically, thus permitting a ready comparison. One chapter is devoted to the purpose and basis of lumber grades. Standard sizes of lumber are given a separate chapter. Unfortunately the chapters on grading and standardization were printed before the adoptions, recently, of standard sizes by all associations. How lumber is measured, and the standard weights of finished products are given attention in two chapters. Chapter VII on structural timbers is one of the most valuable in the book. The three chapters following are devoted to seasoning, wood preservation and paints and wood finishes. The paragraph on the savings due to preservative treatment seems to have been eliminated, instead it should have been retained and amplified; interest in wood preserving is increasing, and the user always wants to know what gain may be expected by treating his material. Follow chapters on wood block paving, hardwood flooring, fire resistance and lumber prices.

Chapter XV on the uses of lumber is of great value because of its many tables listing the percentage of the various woods used in the many wood using industries. Chapter XVI describes the principal commercial woods of the United States with tables indicating their uses. In view of the increasing importance of western woods they should have been given uniformly greater space to better advise the prospective consumers as to their properties and utility. The confusion concerning the nomenclature of western woods, principally Idaho white pine, western yellow pine, and Douglas fir worries many eastern buyers and this should have been more definitely cleared up.

This book has become somewhat of a standard for the man who desires general information on lumber, and in the short space allotted to each topic the author has indeed done well. For the more searching student, government and other special publications will still be the main storehouse of information. E. F.

Comparison of Woods for Butter Boxes. By G. D. Turnbow. Bulletin 369, College of Agriculture, University of California, Berkeley, Calif., 1923. 10 pages, 5 figures.

One of the greatest problems of the lumberman is the discovery or development of uses and markets for his so-called inferior species. Such discovery not only benefits the operator in reducing unit operating costs but it eventually and very materially benefits the lumber-consuming public.

The bulletin here considered opens a new field for the white fir of the Sierra pine forests of California. Heretofore this wood was considered undesirable for such an exacting use as a butter container because of its odor. The bulletin reports the results of an investigation conducted by the Division of Dairy Industry, University of California, to determine the possibility of substituting white fir and cottonwood for spruce, heretofore the standard butter box wood.

The butter for cold storage was packed in white fir, cottonwood, and spruce containers holding ten pounds each. Both seasoned and unseasoned woods were used in each of the three methods of packing.

"The first set packed with butter were of plain unseasoned boxes of each of the woods. The second set had the inner surface paraffined before packing. The method of paraffining was to invert the box

over a steam jet and steam thoroughly. This served a double purpose in that it opened the pores of the wood and allowed the paraffin to penetrate, and the heated surface of the wood kept the paraffin in a liquid condition so that it could be put on in a thinner coat than if the paraffin had been applied to a cold surface. After the boxes had been allowed to drain, the inside was then painted with paraffin at 240° F. This method gave a complete covering to the wood, a result which is not always obtained by some of the commercial paraffin atomizers. The third set was paraffined as above and, in addition, lined with good parchment paper so that no butter could come in contact with either wood or paraffin. Twenty-three 10-pound boxes were packed in the three ways."

The investigation led to the conclusion that cottonwood is the equal of spruce as a butter container, and that white fir may be used very successfully. The latter scored only 0.381 of a point below spruce. After six months storage none of the cubes packed in seasoned, paraffined and parchment lined containers received a cut directly due to wood flavor. An important general conclusion drawn from the report is to the effect that, regardless of the wood used, the container should be made of well seasoned lumber and should be carefully paraffined and parchment lined. E. F.

Some Results of Cutting in the Sierra Forests of California. By Duncan Dunning. U. S. Dept. of Agri. Bull. 1176.

The object of the study resulting in this bulletin is to determine cutting methods for the Sierra Forests of California that will secure adequate reproduction and retain desirable advance reproduction and immature timber for its growth after cutting. Four forest types were studied, namely, pure western yellow pine; yellow pine-sugar pine; mixed yellow pine-sugar pine, Douglas fir, white fir, incense cedar; and sugar pin-fir. Results are to be used as a basis for revision of marking rules and a building up of good "silvicultural practice" for that region.

Conclusions are based on periodic observations and measurements of 25 sample plots, totalling 300 acres and 13,000 trees, established in 1911 on National Forest cut-over areas in the Sierra belt near Mount Shasta. The plots were distributed over as many variable of site, type, and

degrees of cutting as offered by the region and cutting methods in vogue at that time.

Dunning takes up first the growth of stands remaining after cutting and lists the influencing factors in order of their importance, as follows: "Site, species, size and age, crown size and form, degree of cutting." He has prepared tables showing growth per cent as affected by variations of the above factors.

"On sites 1 and 2 a reserve volume . . . is justified for increased growth and improved quality of second cut," but on site 3, or poorer, accelerated growth was in no case sufficient to justify reserving merchantable timber for this purpose and cutting should aim to secure reproduction only.

"White fir ranks first in rate of growth, followed by sugar pine, Douglas fir, yellow pine, and incense cedar. Sugar pine maintains a high rate of growth to a greater age and diameter limit than other species."

The rate of the released growth was found to vary more in proportion to length of crown than to any other crown characteristic. It is interesting to note that Chapman found this to be the case in longleaf and loblolly pine of the South, and it seems probable that this may hold true in conifers of all regions.

The author brings out forcefully the rather elementary silvicultural facts that no acceleration of growth occurs in groups of trees after cutting where there has been no cutting in the interior of the group, or in open-grown stands where no competition existed before cutting. He states more specifically, however, that "no acceleration is observable unless trees are removed within 50 or 60 feet" of the tree reserved. The exact relation between degree of cutting or release, and amount of accelerated growth seems to have been obscured by uncontrolled variables on the plots studied.

The discussion on reproduction emphasizes great necessity for taking all possible care to preserve reproduction already on the ground before cutting, because of the difficulties and length of time involved in securing reproduction after cutting. These difficulties are attributed to "drought and infrequency of seed crops on poor sites," and on the better sites to competition with vegetable ground cover, insufficient opening up of the stand by cutting, and infrequent seed crops." It is recommended that the present practice of piling and burning brush be abandoned, the contention being that burning results in "covering

by fire of at least 6 to 10 per cent of the area, on which a considerable number of seedlings and saplings are destroyed," and "that areas covered by fires are rendered unfavorable to establishment of seedlings for several years." Although the author admits that "exposure of mineral soils and openings created by fire favor yellow pine" he advocates that piling and burning of brush be dispensed with for the region as a whole. Pearson in the Southwest recommends general piling and burning of brush in yellow pine type. Apparently the loss of yellow pine reproduction by burning brush in the Sierra region as a whole offsets any advantage gained by opening up seed beds of mineral soil.

In conclusion, figures are exhibited to show that after all, on areas devoid of advance reproduction, restocking by artificial planting would be less expensive than depending on natural reproduction, when all costs and values of each method are considered.

E. W. HADLEY.

Ranger District Number Five. By H. S. Moles. The Spencerian Press, Boston, 1923. Pages 350, ill.

Professor Moles of the State College, New Mexico, in collaboration with Anna Wells, has written a book which deals with the early days of the Forest Service in New Mexico. Specifically, the story, which is in the form of a novel, tells of the struggles in getting started when the Jemez[1] was young. The first part tells of rangers who undoubtedly were employed in the General Land Office, since they would not have been tolerated in the Forest Service.

The villain of the story is a wealthy Mexican who owns cattle and sheep and who holds his followers in line by keeping them in debt to him. He has the attributes of the political boss and fills county offices at will.

Of course this villain clashes with the administration of the forest reserve, particularly on matters of range control. The second batch of rangers is a hard riding, hard shooting lot, and would not rank very high in efficiency, judged by present-day standards. However, they are romantic, and while they do not get much done their adventures make interesting reading.

[1] Jemez was never under the Land Office. I examined it for proclamation in 1905.—R. V. R.

The stories were told the author by a ranger, Arthur J. Wells, on the Jemez from 1909 to 1912. Therefore the characters in the book are actual people given other names, and the time is about 1909 or 1910. The reviewer is personally familiar with the place and time, since he was forest assistant on the Jemez in 1906. Therefore he can guess that the scene is in the vicinity of Cuba, New Mexico; that the villain Ortega is undoubtedly a certain well known character now dead, who held the country in terror for years.

Old "Mac," the forest supervisor, is probably McMillen. There was nothing old about "Mac" and he had few of the "silent man of the range" characteristics which the author gives him, but many shrewd sayings and keen observations are typical of the former supervisor. The forest inspector is a curious bit of portrayal and does not instill much confidence in the Forest Service's judgment in selecting inspectors. The District 3 Daily Bulleting of December 11 suggests that this inspector, named Ensley, is likely T. S. Woolsey, Jr., but the likelihood seems remote to one who knew Mr. Woolsey in those days.

The book as a whole is disappointing in that it fails to bring home to the reader the real merits of the work which the Forest Service has done and is doing in the Southwest. There is little of the actual every-day work of the ranger and supervisor. Adventure is all well enough in its place, but those who have been through the mill know that it is only the spice which enlivens the real accomplishment of organizing the National Forests in the early days.

A. B. R.

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NOTES

Waiotapu Plantations

The January issue of *Te Karere o Tane,* the monthly newsletter of the New Zealand State Forest Service, contains a brief report on the Waiotapu plantations which should be of interest to American foresters. Planting was commenced in 1902, but results were unsatisfactory at first because of summer frosts. Eucalypts were practically a complete failure, while *Pinus strobus* and *P. radiata* suffered severely, and other conifers (except *P. ponderosa*) to a less extent. In 1907 the eucalypt plantations were restocked with larch, which soon grew tall enough to escape frost injury and at the same time to afford shelter for the eucalypts. These commenced to grow in 1912, by 1920 overtopped the larches, and in 1922 suppressed them. Average growth in diameter and height of the various species was as follows:

	Age, years	*Hight, feet*	*D. b. h., inches*
Pinus austriaca	21	40.2	7.1
Pinus coulteri	19	44.4	6.7
Pinus Jeffreyi	21	40.3	10.0
Pinus lambertiana	17	26.9	6.0
Pinus laricio	21	55.8	10.6
Pinus murrayana	16	50.4	6.5
Pinus muricata	19	67.9	10.4
Pinus ponderosa	18	44.9	8.9
Pinus pinaster	19	42.9	7.4
Pinus radiata	20	91.4	13.3
Pinus rigida	16	30.0	5.0
Pinus strobus	18	43.0	7.5
Pinus teocote	12	46.9	5.5
Pinus torreyana	19	44.9	5.9
Eucalyptus coriacea	21	40.9	5.1
Eucalyptus coccifera	21	47.0	7.6
Eucalyptus ovata	21	87.0	10.2
Eucalyptus obliqua	21	40.0	6.4
Eucalyptus risdoni var. elata	21	62.0	7.5
Eucalyptus sieberiana	21	53.5	5.7
Eucalyptus viminalis	21	79.0	13.9
Larix europaea	21	50.0	11.0
Larix leptolepis	8	17.9	2.8

Foresters of the Pennsylvania Railroad System

The work of the foresters of the Pennsylvania Railroad System, which was briefly described by John Foley in a paper read at the annual meeting in Baltimore in December and published in the Journal for February, has been extended to cover the inspection of forest products and their preservative treatment. The approximately 100 men engaged in this work are located in all of the wood-producing sections of the country except New England and the Rocky Mountains.

SOCIETY AFFAIRS

Winter Meeting of the Allegheny Section

The winter meting of the Allegheny Section of the Society of American Foresters was held at Harrisburg, Pa., on February 29, 1924. Forty-five members attended and participated in an interesting program. This was the largest attendance at any meeting since the Section was organized three years ago.

The Secretary's report shows that the Allegheny Section now has 105 members, of which 75 reside in Pennsylvania, 13 in New Jersey, and 7 in Maryland. A very substantial increase in membership was made during 1923, when 36 new members were added—an increase of more than 50 per cent during the last year.

The program was as follows:

"Free Forest Trees—Is Pennsylvania's Policy Sound?" John W. Keller.

"Public or Private Production of Planting Stock—Which?" A. D. La Monte.

"Observations and Experiences of a Forest Surveyor." Capt. S. T. Moore.

"History of Forest Land Purchase in Pennsylvania." A. E. Rupp.

"Suggestions for the Promotion of Practical Forestry in the General Farm Sections of the Northeast." J. O. Hazard.

"Salvaging Blighted Chestnut." W. H. Horning.

"Where our Wood Goes." J. S. Illick.

"How Fire Changes Forest Types." E. F. Brouse.

"Recent Progress in Pennsylvania Forest Nursery Practice." George S. Perry.

The officers elected for the coming year were: Chairman, John Foley; Vice-Chairman, Lewis E. Staley; Secretary-Treasurer, Joseph S. Illick.

On invitation of the foresters of Maryland, it was decided that the summer meeting of 1924 be held on the Eastern Shore of Maryland, where many interesting forest projects are available for demonstration.

Recent Elections to Membership

The following candidates have been elected to the grade of Member:

Burley M. Lufburrow, Moulton, Ala. Effective April 21, 1924. Nominated by the Southern Appalachian Section.

J. E. Myer, Milford, Pa. Effective April 21, 1924. Nominated by the New York Section.

James R. Gillis, Bureau of Forestry, Manila, P. I. Effective April 23, 1924. Nominated by Arthur F. Fischer, John F. Preston, and J. V. Hofmann.

Southwestern Section

At the annual meeting of the Southwestern Section, held at Albuquerque on February 25, the following officers were elected: Chairman, J. C. Kircher; Vice-Chairman, H. G. Calkins; Secretary, Quincy Randles.

The Section will hold two meetings, one in March and one in April, at which papers prepared by Aldo F. Leopold and Joseph Kircher will be delivered.

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